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ABSTRACT

The forecast reported here surveys expected utilization levels, organizational structures, and values concerning technology in education in 1990. The focus is upon educational technology and forecasting methodology; televised instruction, computer-assisted instruction (CAI), and information services are considered. The methodology employed involved: 1) asking experts to predict levels of technological utilization and their impacts upon structures and values; 2) providing feedback to them; and 3) obtaining revised estimates. The seven chapters introduce the subject, analyze forecasting methods, review previous studies, define terms, describe the design and execution of this forecast, present results, and critique the methodology used. Some major findings reported indicate that cable television will be widely available and used, that televised instruction will be common, and that CAI will be moderately widespread. Public control and financing of delivery systems will prevail and software will be available through national organizations. Also, technology will be used in coordination with teachers who will become learning managers and resource persons. Finally, education will become capital-intensive and will require cost-effectiveness. (Author/LB)

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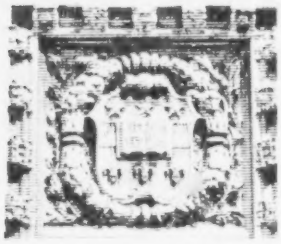

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A DELPHI FORECAST OF TECHNOLOGY IN EDUCATION

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A DELPHI FORECAST OF TECHNOLOGY IN EDUCATION

BURKE E. ROBINSON

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OVERVIEW AND RATIONALE

(Why Should I Read this?)

This report presents the results of a Delphi forecast of the utilization and social impacts of large-scale educational telecommunications technology. The forecast is part of a continuing interdisciplinary study of the potential application of communications satellites to educational development in the United States, supported by the National Aeronautics and Space Administration at the Center for Development Technology, Washington University, Saint Louis, Missouri. The research also fulfills the Master of Arts thesis requirement in the university's Program in Technology and Human Affairs.

In some of the previous work in the satellite-education study, rough estimates were made of 1975 and 1985 utilization ranges of various educational telecommunications services. The forecast reported here is an attempt to expand upon this previous work by forecasting utilization levels, organizational structures, and values and opinions concerning technology in education in 1990. Subsequent work will deal with more detailed analyses of the political, social, and economic impacts of technology in education as well as the design of alternative educational telecommunications systems.

The focus of this report is upon both forecasting methodology and educational technology. The first chapter introduces the subject area; the second chapter critically analyzes the various methods of forecasting used by futurists from the perspective of the most appropriate method for a prognosticator of educational technology. The

third chapter is a review and critical analysis of previous forecasts and studies of educational telecommunications technology, including reports by: the National Academy of Engineering; Lockheed Missile and Space Company; the Carnegie Commission on Higher Education; Bell Canada; Anastasio and J. S. Morgan; and R. P. Morgan, Singh, Anderson, and Greenberg. The fourth chapter defines the terms to be used, including educational technology, educational environments, utilization levels, and social impacts; the fifth chapter describes the design and execution of the forecast. The results are presented in the sixth chapter in three parts: graphic responses, summarized comments, and a scenario of education in 1990. The seventh and final chapter contains a critique of the methodology used in this Delphi forecast and suggestions for future improvements. An Appendix lists the names of the participants in the forecast.

Large-scale educational telecommunications technology, as used in this forecast, includes the following:

television instruction--dissemination of programming through broadcast television, cable television, videocassettes, etc.;

computer instruction--two-way, interactive programming with individualized content and pacing, such as computer-assisted instruction;

information services--information available electronically through interconnected networks of libraries and computers, including computerized libraries, educational data banks, time-shared computers, etc.

Education includes early childhood, primary and secondary, higher, vocational and technical, adult and continuing, and special education; each of these types of education can occur in public institutions,

private institutions, or home and other informal environments. Utilization levels, which are forecast for both 1980 and 1990, are expressed as the percentage of locations in which technology is used in some aspect of the educational process. Social impacts are the organizational structures for large-scale delivery and software supply systems as well as values and opinions of people in the future.

The design of this Delphi forecast began with the selection of experts with interests in education, communications technology, and a wide variety of other areas. Of 123 invitations to participate, 49 people responded to Round One and 39 of those responded to Round Two. There was a noticeable lack of responses from teachers and administrators in primary and secondary education. The format was designed to encourage imaginative forecasts by asking respondents to imagine themselves in a time machine which takes them to view education in the future. The Delphi methodology used included two rounds; the first asked for forecasts of utilization and social impacts of technology in education, and the second gave feedback on the responses and comments from the first round, allowing revisions in the estimates where desired by the participants.

The results portray the future of technology in education in 1990 as follows:

> Cable television will be widely available and provide educational and informational services; satellites will be used to transmit over long distances. Use of television instruction will generally be heavy (60 to 79 percent of educational locations) with programming of sufficient quality and diversity. Computer instruction will be in developmental use (20 to 39 percent of educational locations), except in higher and vocational and technical education where utilization will be moderate (40 to 59 percent of educational locations). Information services will be in moderate use in public and private institutions but only in developmental use in the homes. Higher and adult and continuing

education will make more use of these services, and early childhood education will make less use.

Public control and financing of the delivery systems will prevail; there will be more local and state rather than regional and national operation and co-ordination of these distribution systems. Software will be made available through organizations which are national rather than local; the control and financing of software will be half public and half private. The user will be able to schedule half of the programs, and the costs of use will be partially subsidized.

Funding will be one of the major obstacles to use of technology in education. National political indecision may delay use in public schools. Private schools, in cooperation with private corporations, may develop early successful experiments with educational technology in the areas of early childhood education, vocational and technical education, adult and continuing education, and special education. The pressure for equality of educational opportunity and individualized instruction may encourage greater acceptance of educational technology.

Technology will most often be used in coordination with teachers to do a better job at the same costs as before; there will be little acceptance of substituting technology for teachers to do the same job at the same costs as before. Education will become more capital-intensive and thus use cost-effectiveness, accountability, and productivity measures, but there will be problems in that causal relationships in education are difficult to establish because of the complex interaction of subjective variables. Privacy of information will be safeguarded, but adequate copyright protection becomes a problem when allowing open access to information. Educational opportunities will be provided for everyone, regardless of socioeconomic background; poorer schools will receive financial assistance to help them obtain educational technology.

Educational values will be changing. Teachers will no longer fear technology; in fact, they will have adapted to new roles as learning managers and resource persons, assisted by a variety of para-professionals and media specialists. Education will be a lifetime experience, available at most any time in most any place. Although schools will still perform functions as socializers, custodians, and certifiers, human organizations will become multi-purpose--recreation, career, and education will be blended together.

These results may be overly optimistic. The definitions are very broad, utilization levels do not include the number of hours the technology is used, and social impacts are not analyzed for specific categories of education. The design may have encouraged those people with interests in educational technology to respond, while discouraging

those with little interest. No preliminary estimate was made to see what levels of utilization exist currently.

On the other hand, the results may be overly pessimistic. The technology may be far more revolutionary than imagined. Current negative attitudes toward education and technology may become positive in the future.

Or, the results might represent an accurate picture of the future of technology in education. They are somewhat similar to the results of the Bell Canada study and to a scenario written by Edwin Parker.

Suggestions for improving this forecast include expanding the definitions, selecting a larger panel of experts, and analyzing the social impacts more completely. This forecast could be used as a starting point for a thorough assessment of the trade-offs and consequences of educational technology in complex interaction with political, social, and economic forces.

Although this overview and rationale has emphasized those aspects of the report which are most pertinent to people with interests in educational technology, the report also contains a review and critical analysis of forecasting methodology. To encourage the reader to read more than this overview, an attempt has been made to make the subject more interesting or less boring by adding bits of literary wisdom: the advice of the White Queen and the Cheshire-Cat to Alice, Mark Twain's view of science, Unamuno's thoughts on planning, and Plato's observation about madness.

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Chapter 1

INTRODUCTION

(What Are You Trying To Do?)

> "That's the effect of living backwards," the Queen said kindly: "it always makes one a little giddy at first——"
>
> "Living backwards!" Alice repeated in great astonishment. "I never heard of such a thing!"
>
> "——but there's one great advantage in it, that one's memory works both ways."
>
> "I'm sure mine only works one way," Alice remarked. "I can't remember things before they happen."
>
> "It's a poor sort of memory that only works backwards," the Queen remarked.
>
> "What sort of things do you remember best?" Alice ventured to ask.
>
> "Oh, things that happened the week after next," the Queen replied....[1]

Lewis Carroll [pseud.] uses the concept of "backward living" and a somewhat different definition of "memory" to point out very cleverly the advantage of having some knowledge of the future on which to base one's actions. In this thesis an attempt is made to "live backwards" in the area of educational telecommunications technology using the Delphi method to sharpen the "memory" process. After presenting critiques of methods of forecasting and of previous forecasts of educational technology, the Delphi forecast done for this thesis is examined in four steps: definitions, design, results, and critique. The purpose

is to explore the methodology as much as it is to look at the future of technology in education.

Methods of forecasting, whether they are those of Gypsy fortune-telling or those of technological forecasting, arouse suspicions. Winston Churchill said, "It is always wise to look ahead, but difficult to look further than you can see."[2] Churchill further noted:

> The most essential qualification for a politician is the ability to foretell what will happen tomorrow, next month, and next year, and to explain afterwards why it did not happen.[3]

This could easily be the shortcoming of a forecaster as well as a politician. In a similar vein, Mark Twain [pseud.] engages his wit to criticize scientific methods of prediction:

> In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself two hundred and forty-two miles. That is an average of a trifle over one mile and a third per year. Therefore, any calm person, who is not blind or idiotic, can see that in the Old Oölithic Silurian Period, just a million years ago next November, the Lower Mississippi River was upward of one million three hundred miles long, and stuck out over the Gulf of Mexico like a fishing-rod. And by the same token any person can see that seven hundred and fifty-two years from now the Lower Mississippi will be only a mile and three-quarters long, and Cairo and New Orleans will have joined their streets together, and be plodding comfortably along under a single mayor and a mutual board of alderman. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact.[4]

With healthy skepticism such as this, a prudent prognosticator, in search of a methodology, would probably do well to examine critically all available techniques of forecasting. The Delphi method is one mouse in a field of hundreds; the range of possible approaches to the future extends from those of science fiction writers and revolutionary futurists to those of social planners and professional futurists.[5]

Before choosing to use the Delphi approach, a critical analysis of other possible techniques is contained in Chapter 2.

The same critical attitude is continued in Chapter 3 where previous forecasts and studies of educational technology are reviewed and appraised, including reports by:

the National Academy of Engineering;[6]

the Lockheed Missile and Space Company;[7]

the Carnegie Commission on Higher Education;[8]

Bell Canada;[9]

Anastasio and J. S. Morgan;[10] and

R. P. Morgan, Singh, Anderson, and Greenberg.[11]

New forecasts would enhance their utility by attempting to improve upon any limitations of these previous efforts. The Delphi forecast in this thesis is an attempt to make such improvements. In particular, the intent is to examine potential utilization and social impacts of large-scale educational telecommunications technology--that technology which could be organized for distribution through large systems and networks. An attempt is also made to consider a complete range of educational technology in a complete range of educational environments.

Once a methodology has been chosen and current literature in the field reviewed, the forecaster is then ready to launch a new study. This requires the expenditure of a great deal of time and effort--time and effort in the preparation of workable and flexible definitions, time and effort in the design of a concise and complete study, time and effort in the execution of an efficient study, as well as time and effort in the evaluation of carefully summarized results--to arrive at a plausible "futurible" (possible future).[12] Chapter 4

contains the definitions for this study, Chapter 5 contains the design and a description of the execution of this study, and Chapter 6 contains the results of this study.

Finally, in Chapter 7, the circle is completed, and a critique of this Delphi study is undertaken. Limitations and suggested improvements relating to this study are described, including a couple of crucial caveats for those using the results. Lest anyone become enamored with the results, the methodology, or the technology in this study, a Commander of the Royal Navy has one such caveat:

> "That piece of equipment is so ingenious; looks so beautiful; and works so well; it almost makes me forget how utterly useless it is."[13]

Chapter 2

CRITIQUE: METHODS OF FORECASTING

(How Would Somebody Do That?)

Among the many methodologies for forecasting or surveying the future, only a few are dealt with here in any detail. Brief consideration is given to the approaches of nonprofessional futurists, including science fiction writers, brainstormers, revolutionary futurists, social evolutionaries, social planners, and ecological futurists.[14] Greater attention is given to the techniques of professional futurists, who see forecasting as dualistic, that is, composed of normative and exploratory methods.[15] Greatest attention is given to three types of exploratory forecasting: trend prediction, modeling, and intuitive methods.[16] At the end of this critique, the focus turns to some of the more general limitations of any method of forecasting.

NONPROFESSIONAL FUTURISTS

The capacity of science fiction writers for making accurate forecasts is apparent in the writings of Jules Verne and Arthur C. Clarke.[17] Few forecasters have powers of imagination or abilities in analysis and synthesis comparable to these artists, as noted in this observation:

> A review of the most important forecasts made in the past reveals an almost universal lack of attention to such questions

> as how the different parts of a future society will interact, how they will influence each other, and how they will function together. Perhaps the best examples of 'knitting together' are provided by what is essentially an art form--science fiction.[18]

And there is a need for this type of thinking in the world today.[19]

Brainstormers attempt to jar their thoughts out of conventional "grooves and ruts" through a process of listing any and every idea pertaining to the solution of a given problem. Groups involved in brainstorming usually defer judgment on the ideas expressed until after the session is finished, allowing uninhibited expression of novel solutions to occur. Brainstorming has been incorporated into William J. J. Gordon's technique of "synectics"[20] and Edward deBono's "zig-zag" thinking.[21]

Common to most varieties of revolutionary futurists is a desire to actively transform society in some way which they deem a betterment of the human condition. Methods are both political and nonpolitical, violent and nonviolent; tactics vary from emphasis on international organizations to emphasis on interpersonal communities, from liberation movements to peace movements.[22] In all cases the spirit is for revolutionary change, and in some cases it is felt that future changes cannot be predicted until after the revolution.

"Cultural brainstorming", keeping in mind the lessons of history and experience, is the approach of social evolutionaries toward the future.[23] They strive to keep open networks of communication with gifted people who share concerns for the future, people like Margaret Mead, John Platt, John McHale, Buckminster Fuller, Ralph Tyler, and Marshall McLuhan.[24]

Social planners and systems designers are usually engaged in figuring trade-offs among political, social, and economic variables to arrive at a balanced and planned development program.[25] Having achieved moderate successes in socialist countries for the past fifty years, this approach has now been adopted in other countries of the world for various urban, regional, and national planning strategies.[26]

Aided by the astronaut's view of Spaceship Earth, the new breed of ecological futurists is trying to develop a concern for global environmental and resource problems. Their methods range from romantic fantasy to scientific fact, as seen in the writings of the Aquarian Oracle, the Whole Earth Catalog, Teilhard de Chardin, Kenneth Boulding,[27] Paul and Anne Ehrlich,[28] and Barry Commoner.[29]

While the holistic, creative nature of these approaches is appealing, this imaginative nature may also be the most significant shortcoming. To one degree or another, all of these techniques are hindered because they are similar to "genius forecasting"; that is, they require of the forecaster qualities of brilliance or training in highly original thinking.[30] Ralph Lenz has said that such methodologies are of doubtful benefit because, "They are impossible to teach, expensive to learn, and allow no opportunity for review by others."[31] Considering these limitations the forecaster would probably do best to examine other methodologies.

PROFESSIONAL FUTURISTS

The professional futurists have been busy turning forecasting from an art into a science, picking up jargon, definitions, and fancy

approaches along the way.[32] Roy Amara and Gerald Salancik, of the Institute for the Future, offer the following, refreshingly simple, definition of a forecast:

> forecast - a probabilistic, reasonably definite statement about the future, based upon evaluation of alternative possibilities.[33]

Erich Jantsch, pioneer in the field of forecasting, explains the difference between normative and exploratory methods thusly:

> normative, or mission-oriented methods, start with an assessment of future needs, goals, or desires and work backward to the present; while,
>
> exploratory, or opportunity-oriented methods, start from the current base of knowledge and project into the future.[34]

The interaction of these two methods within some time-frame is the process of forecasting.[35] Marvin Cetron, another respected figure in the field, cautions that forecasting describes what the future could be, and not nessarily what the future will be.[36]

Normative Methods

The essence of the normative approach to forecasting is expressed by Norbert Wiener:

> There is one quality more important than 'know-how'.... This is 'know-what' by which we determine not only how to accomplish our purposes, but what our purposes are to be.... Whether we entrust our decision to machines of metal, or to those of flesh and blood which are bureaus and vast laboratories and armies and corporations, we shall never receive the right answer to our questions unless we ask the right questions.[37]

In spite of the complex, mathematical nature of various normative techniques, it is this spirit of concern for values and goals which permeates the process.[38]

Examples of these methods range from simple linear programming to complex systems analyses. Linear programming and solving simultaneous equations are part of operations research and decision theory methods.[39] Network techniques, relating subsystems to larger systems, as seen in PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method), were first used for military forecasting and planning.[40] Gaming is employed to simulate multiple interactions occurring among planners (players) making decisions (moves).[41] Relevance tree techniques are found useful in analyzing needs in outline form, step by step, starting with the lowest level and working up to the highest.[42] Methods of morphological analysis utilize diagrams which contain all necessary resources, all possible alternatives, and often all imaginable effects for a given planning problem.[43] Systems analysis, as practiced by the Rand Corporation and Systems Development Corporation, keeps in mind a vision of the entire system while mathematically extracting the most influential factors.[44]

Again, the totality, the comprehensive systems perspective, of these approaches is appealing; however, this highly aggregated and sophisticated nature might prevent these techniques from being applied by most forecasters. Without considerable expertise in mathematical analysis, the forecaster would again be advised to examine other methodologies, but not without a final piece of wisdom from the Cheshire-Cat. Alice was wandering through the Wonderland forest:

> when she was a little startled by seeing the Cheshire-Cat sitting on a bough of a tree a few yards off.

> The Cat only grinned when it saw Alice. It looked good-natured, she thought: still it had very long claws and a great many teeth, so she felt that it ought to be treated with respect.
>
> "Cheshire-Puss," she began, rather timidly, as she did not at all know whether it would like the name: however, it only grinned a little wider. "Come, it's pleased so far," thought Alice, and she went on. "Would you tell me, please, which way I ought to go from here?"
>
> "That depends a good deal on where you want to get to," said the Cat.
>
> "I don't much care where--" said Alice.
>
> "Then it doesn't matter which way you go," said the Cat.
>
> "--so long as I get somewhere," Alice added as an explanation.
>
> "Oh, you're sure to do that," said the Cat, "if you only walk long enough."[45]

Exploratory Methods: Trend Prediction

Familiar to all who deal with trend predictions, the S-shaped curve depicts growth which begins slowly, then increases exponentially, and finally reaches a limit, either natural or man-made, at which it levels off.[46] Slow growth initially is attributed to a lack of technical understanding, to faulty assumptions, and to conventional distrusts; rapid growth then occurs as financial and technical resources are developed, and as social acceptance begins to develop; the tailing off of growth finally comes about as technological opportunities are exhausted, as economic returns diminish, and as societal limits are reached.[47] Four common examples of trend prediction all make use of S-curves: trend extrapolation, envelope extrapolation, substitution analysis, and trend correlation.

Trend extrapolation is the simplest of these examples because it involves merely extending the direction of a particular trend into the future, based upon the historical pattern exhibited by the trend.[48] A hypothetical example of this process might be an extrapolation of the use of snowmobiles in the future (see Figure 1).

Envelope extrapolation, a newer variety of trend prediction, "envelopes" several related trends under one comprehensive curve, which is itself extended into the future, indicating expected growth from presently undiscovered technology.[49] The hypothetical example in this case could be the speed of communication in the future[50] (see Figure 2).

Substitution analysis, at a simple level, is used to extrapolate the growth curve of the substitution of newer technologies for older ones; at a more complex level, it is used to compare growth curves of analogous substitution processes.[51] The hypothetical example here might be a comparison of the curves showing substitution of synthetic fibers for natural fibers in the United States, and in an under-developed country[52] (see Figure 3).

Trend correlation involves the observation that two or more trends relate to each other in a consistent manner historically, and predicts that this relationship will continue in the future.[53] A hypothetical case here could be the correlation between the speed of air travel in military jets and in commercial jets[54] (see Figure 4).

While these methods of trend prediction are currently quite popular, they have major pitfalls. One is that they assume an adequate data base is available from which to construct the historical trend; moreover, that these data are quantifiable and in some sense continuous,

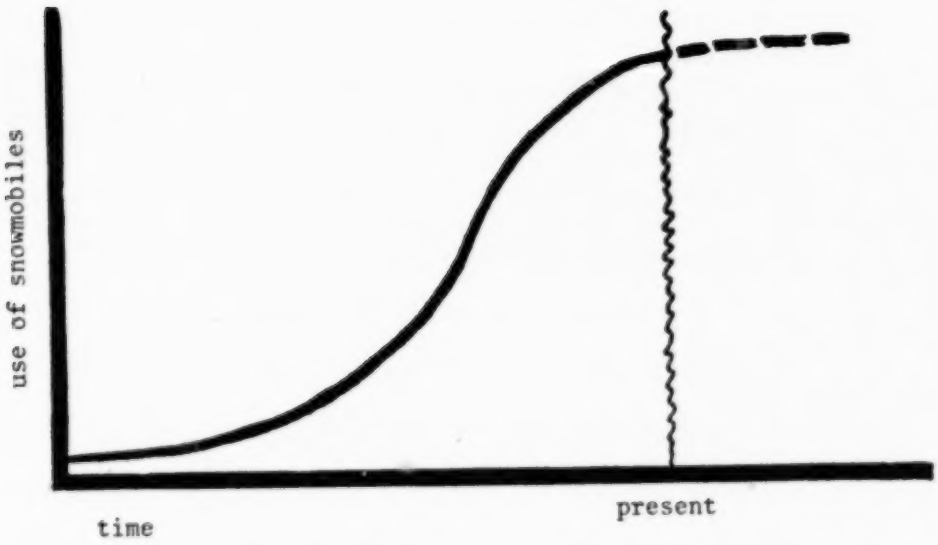


FIGURE 1

TREND EXTRAPOLATION

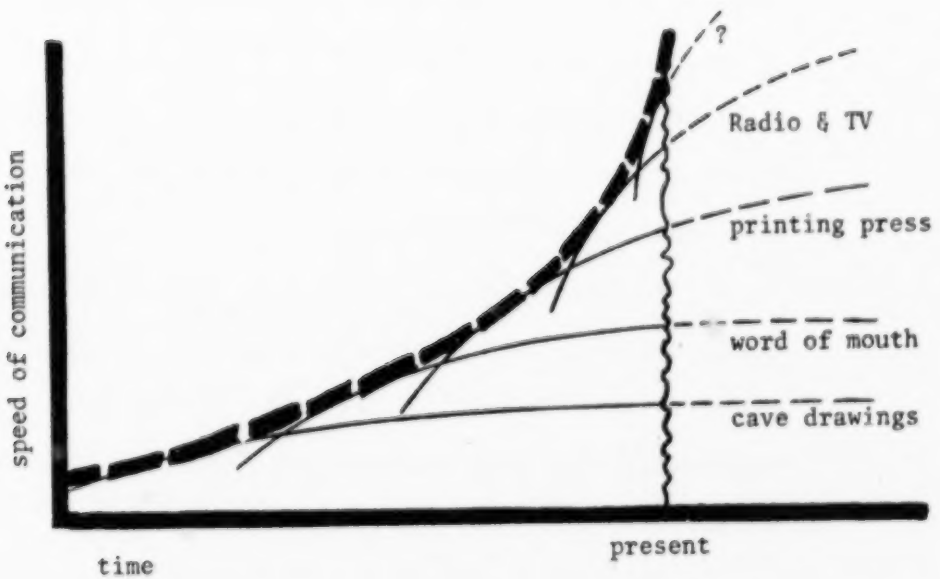


FIGURE 2

ENVELOPE EXTRAPOLATION

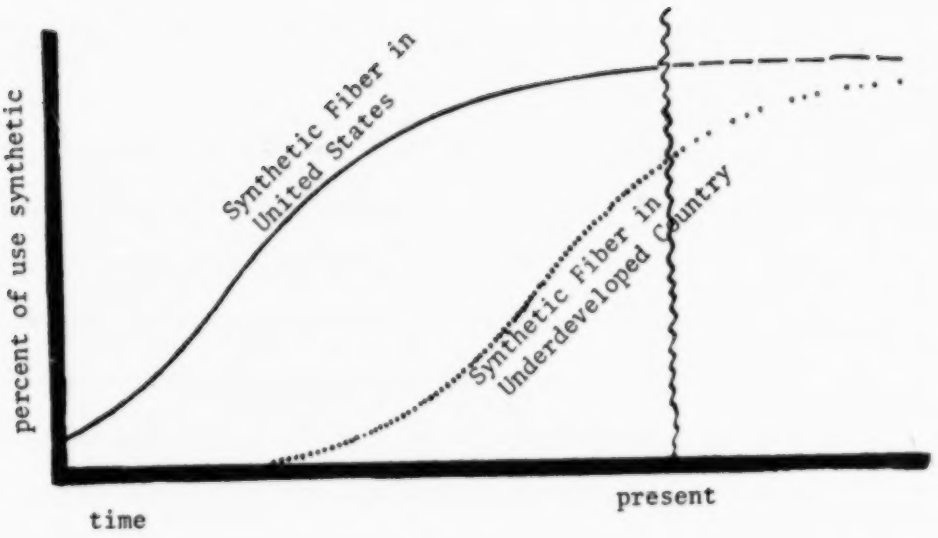


FIGURE 3

SUBSTITUTION ANALYSIS

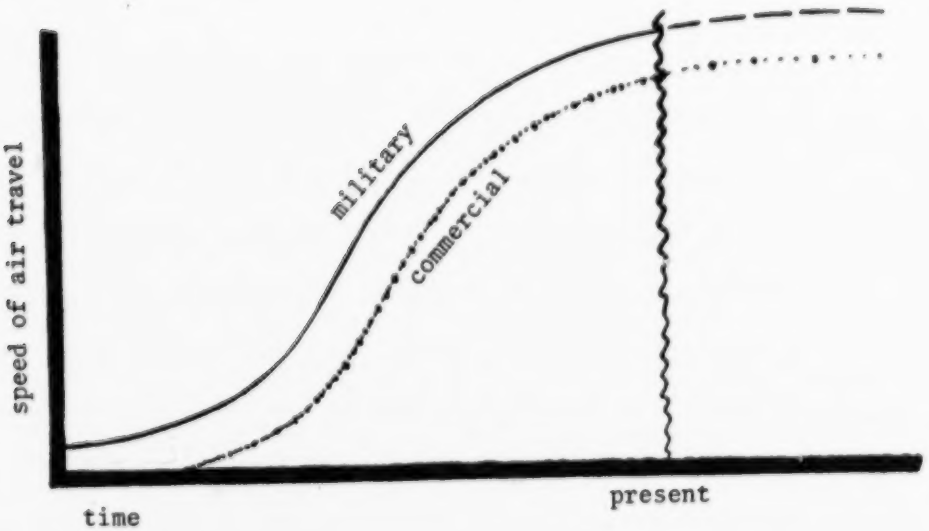


FIGURE 4

TREND CORRELATION

or at least approximated by a continuous curve.[55] Such data are not always available. For emergent technology, still in its infancy, the pattern of growth might not yet be visible, because data are scarce and scattered.

Another pitfall is the disregard of trend interactions--a reason why trend prediction methods should be used in conjunction with normative methods of forecasting. One macro curve represents the net effect of a multitude of subtrends and other variables. It is assumed that those factors causing changes in the trend in the past will continue to do so in the future, and, furthermore, that breakthroughs and other large fluctuations will occur in predictable manners. The future, however, is not so stable and certain. Interacting subtrends can cause the collapse of exponentially increasing growth curves,[57] and shifts in ways of thinking or revolutionary breakthroughs can cause uncertain, unpredictable changes in trends.[58]

The final, major pitfall is the lack of direct concern for the political, social, economic, and environmental forces which could have subsequent consequences for the future growth and development of the predicted trend. While difficulties have been encountered in quantifying social indicators,[59] it seems that the inclusion of these factors in qualitative terms is necessary to avoid incomplete and perhaps erroneous forecasts. For example, taking the hypothetical situations represented in Figures 1-4, some startling changes in future trends can be imagined. Suppose that environmentalists, led by cross-country skiers, were to present claims to legislators showing that snowmobiles were contributing to both noise and air pollution, disturbing natural surroundings by frightening animals and blazing new

trails, and further aggravating the drain on resources by using gas and oil. Future political action severely restricting the manufacture and use of snowmobiles, could cause a sharp decline in their popularity. This type of environmental impact could not be predicted from the trend shown in Figure 1.

Or, take the example of the speed of communication. Suppose a massive social protest against increasing speeds of communication were to occur. Anatol Holt suggests that "next to instantaneous" communication of information, available to everyone on an equal basis, might produce feelings of alienation in the world comparable to placing everyone in solitary confinement.[60] If such fears developed, it is conceivable that the resultant social protest movement would prevent further advances in communication speeds. The noticeable changes due to this social impact are not allowed for in the trend shown in Figure 2.

What would happen in the substitution analysis if environmentalists were to attack substitution of synthetic fibers for natural ones as unecological? Or what if the underdeveloped country were to decide not to produce any more synthetic fibers? The government might feel that maintaining a stable economic program could be better accomplished by encouraging natural fiber industries.[61] Under these conditions, economic forces might cause the growth trend in the underdeveloped country to be different from the trend in the United States, causing errors in the predictions shown in Figure 3.

Similarly, it has already happened that political actions, aided by social, economic and environmental considerations, have limited the speed of commercial aircraft over the United States. The

SST was deemed too costly, too noisy and too unecological to be allowed to fly over the country.[62] Thus, historical correlation with military aircraft speeds will probably not continue into the future, contrary to the forecast in Figure 4.

In summary, when all data are not quantifiable and continuous; when trend interactions are not stable and certain; and when political, social, economic, and environmental forces are of concern; the forecaster should look for a methodology other than trend prediction.

Exploratory Methods: Modeling

Computer simulation or modeling of trends is a method developed at Massachusetts Institute of Technology by J. W. Forrester and recently expanded by Dennis Meadows et al.[63] By solving simultaneous differential equations in time, they have graphically depicted the multiple interactions of trends of growth and development in the world. According to Meadows:

> The basis of the method is the recognition that the structure of any system--the many circular, interlocking, sometimes time-delayed relationships among its components--is often just as important in determining its behavior as the individual components themselves.[64] [emphasis original]

The structure uses feedback loops: positive loops causing growth, negative loops regulating growth, and the interaction among loops contributing to the dynamic behavior modes of the trends.[65] Trends in these models are interpreted qualitatively, according to whether they grow, oscillate, stabilize, or collapse.[66]

Forrester claims that his World Model is realistic in interpreting complex systems as stable and reluctant to change, even though its predictions may seem counter-intuitive.[67] Strategies which

intuitively appear to change the behavior of trends, such as doubling agricultural yields or restricting pollution, only slightly delay an even sharper collapse of trends in the World Model.[68] Strategies which intuitively appear to change the behavior of people, such as implementation of birth control or conservation and recycling of resources, have time delays which subordinate human behavior to systems behavior.[69] Thus, the resultant behavior mode is still collapse for the world trends of population, food per capita, industrial output per capita, resources, and pollution, even after the introduction of intuitive strategies of change[70] (see Figure 5).

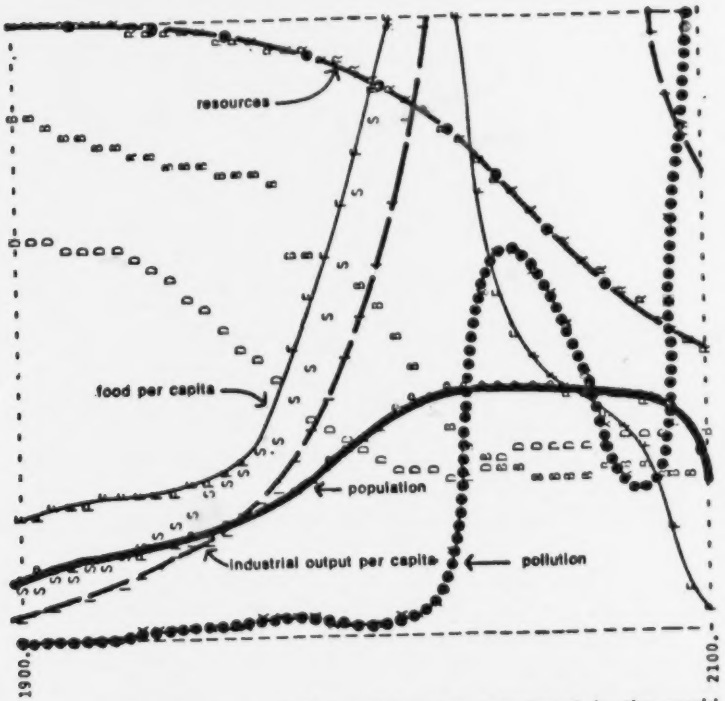
Meadows finds that such factors as peace, social stability, education, and employment are difficult to assess or predict at this stage of the development of world modeling.[71] He further notes:

> The behavior of all complicated social systems is primarily determined by the web of physical, biological, psychological, and economic relationships that binds together any human population, its natural environment, and its economic activities.... The final, most elusive, and most important information we need deals with human values. As soon as society recognizes that it cannot maximize everything for everyone, it must begin to make choices.[72] [emphasis mine]

Meadows recognizes that the model is dealing with the physical variables of man's existence, holding constant the social variables--distribution of wealth, economic choices, allocation of food, family planning attitudes--under the assumption that they will remain the same after a collapse of the trends, which of course they will not.[73]

The modeling approach, however, has considerable merit as a forecasting method. The trends, while based on quantified data, are

WORLD MODEL WITH "UNLIMITED" RESOURCES, POLLUTION CONTROLS, INCREASED AGRICULTURAL PRODUCTIVITY, AND "PERFECT" BIRTH CONTROL



Four simultaneous technological policies are introduced in the world model in an attempt to avoid the growth-and-collapse behavior of previous runs. Resources are fully exploited, and 75 percent of those used are recycled. Pollution generation is reduced to one-fourth of its 1970 value. Land yields are doubled, and effective methods of birth control are made available to the world population. The result is a temporary achievement of a constant population with a world average income per capita that reaches nearly the present US level. Finally, though, industrial growth is halted, and the death rate rises as resources are depleted, pollution accumulates, and food production declines.

FIGURE 5

FORRESTER-MEADOWS WORLD MODEL*

*from Donella H. Meadows et al., The Limits to Growth, p. 140.

interpreted qualitatively. Trend interactions are an important, if not the most important, characteristic of the method. Modeling concerns itself with the dynamic functioning of complex, integrative wholes in much the same way as do normative methods.

Nevertheless, modeling approaches still lack an incorporation of the necessary political, social, economic, and environmental forces. While it can be assumed that certain social parameters are implicitly contained in the behavior of some trends,[74] there are potentially significant factors which are not included. For example, in the World Model, trends of population and industrialization are growing exponentially. As this is happening, it seems imaginable that other trends like urbanization, crowding, disease, and unemployment might also be increasing. Wealth might accumulate in the hands of small and elite groups, while the masses of people continue to get poorer. This inequality in distribution could result in popular uprisings, social upheaval, violence, turmoil, disorder, and perhaps eventually revolution. Though the consequences of these events are significant, none of these factors appear explicitly in either the Forrester or Meadows World Models.

Or, equally as significant might be such factors as the influence of dynamic, charismatic political figures who introduce revolutionary changes into political, social, and economic trends. Such men as Adolf Hitler or Mao Tse-tung, present at particular times in history, are not without their impact upon trends of population, food per capita, industrial output per capita, resources, pollution, etc. These examples illustrate the point that modeling is realistic only

when the assumptions are valid and the inputs are comprehensive. The limitations and incompleteness of current modeling techniques in dealing with social parameters, then, should encourage the forecaster to examine still other methodologies.

Exploratory Methods: Intuitive

The intuitive approach to exploratory forecasting includes scenario writing and the Delphi methodology.[75] Scenario writing, originated by Herman Kahn, of the Hudson Institute, to describe thermonuclear warfare possibilities,[76] is now being used for describing other "futuribles."[77] The Delphi methodology, designed by Olaf Helmer at the Rand Corporation,[78] has likewise been used to forecast a variety of future events,[79] and is considered to be one of the most promising techniques of technological forecasting.[80]

Scenario writing treats the future as a totality; it comprehensively combines the simultaneous interaction of trends and the important political, social, economic, and environmental forces. It necessarily involves the "qualitative properties of intuition, imagination, inventiveness and creativity, and also that of versatility."[81] Exploratory scenarios are written as a chain of related developments which seem plausible in the light of various uncertainties and possible contradictions. Starting with present conditions, each progressive step proceeds in a logically consistent manner from the previous step. Thirteen macro trends dominate most of the scenarios which Kahn writes[82] (see Figure 6). Fred Polak feels that by combining scenario writing with the Delphi methodology, thereby reducing the subjectivity of

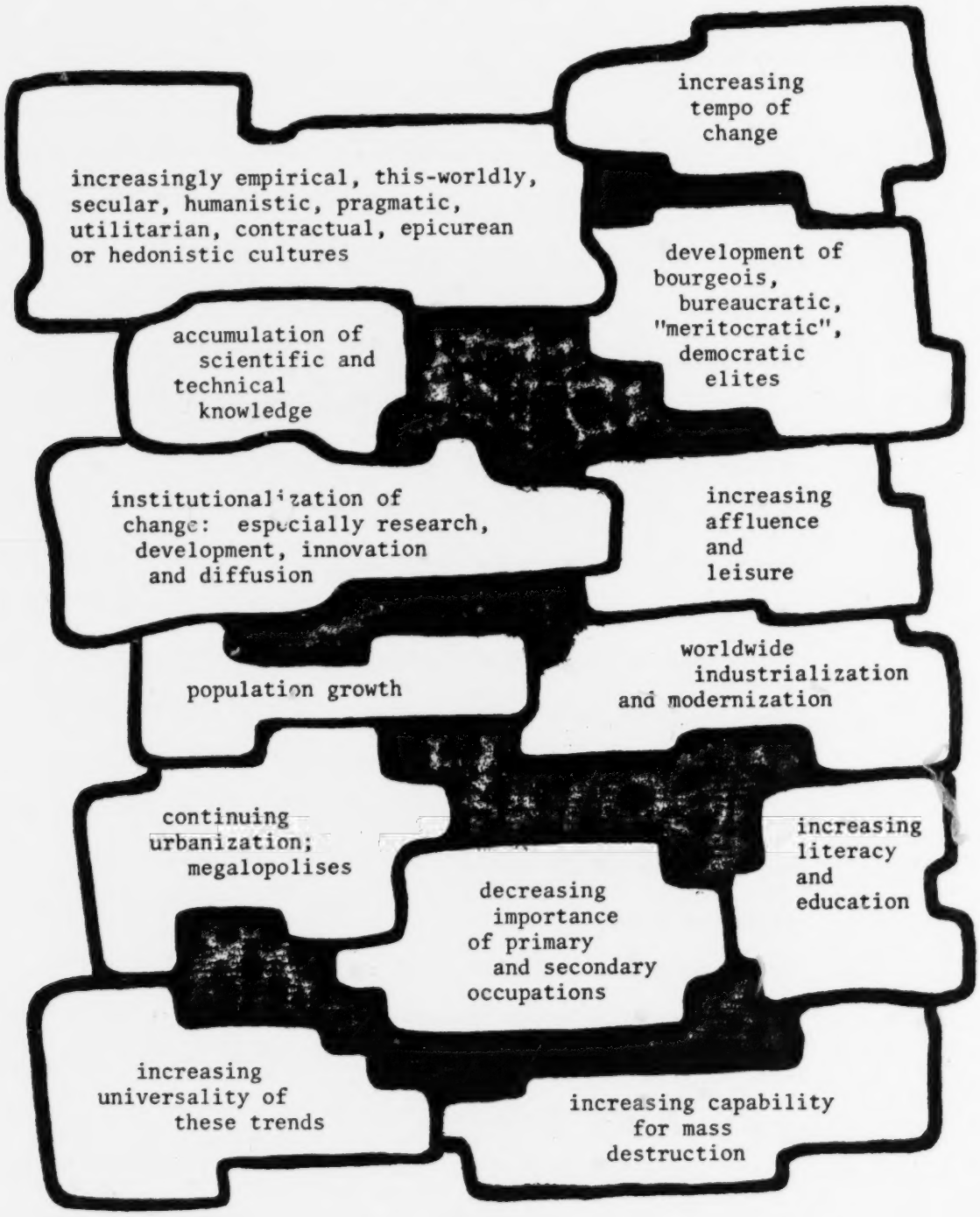

increasing tempo of change
increasingly empirical, this-worldly, secular, humanistic, pragmatic, utilitarian, contractual, epicurean or hedonistic cultures
development of bourgeois, bureaucratic, "meritocratic", democratic elites
accumulation of scientific and technical knowledge
institutionalization of change: especially research, development, innovation and diffusion
increasing affluence and leisure
population growth
worldwide industrialization and modernization
continuing urbanization; megalopolises
increasing literacy and education
decreasing importance of primary and secondary occupations
increasing universality of these trends
increasing capability for mass destruction

FIGURE 6

HERMAN KAHN'S THIRTEEN MACRO TRENDS*

*adapted from Herman Kahn and Anthony J. Wiener, "Faustian Powers and Human Choices," in Futures Conditional, p. 57.

scenarios, it is possible to arrive at reasonably accurate visions of the future.[83]

Delphi is a method which attempts to extract opinions on a particular subject from a panel of experts assembled from various fields. The panel is presented with a sequence of questionnaires, usually by mail, which try to establish some form of consensus among the respondents as to the likelihood of selected future events.

Two of the major, distinguishing features of a Delphi study are the feedback of results and the anonymity of the responses.[84] Each succeeding round of the study includes a graphic representation of the median response and the middle 50 percent of the responses for each question from the previous round. Further feedback is presented in the form of summarized, anonymous comments from those participants whose responses fell outside of the middle 50 percent ranges. The purpose of feeding back the responses and the comments is to encourage those panelists who feel less certain of their responses to move in the direction of the median, and thus to arrive at a consensus opinion as to the future likelihood of the events. Anonymity of the responses is maintained to avoid the undesirable features of interpersonal, group communications, such as the dominating personality, the bandwagon effect, insufficient attention to minority viewpoints, and digressions from the topic of discussion.[85]

Helmer also stresses the importance of obtaining qualified experts, and then making full use of their knowledge and abilities. Respected experts are chosen from both generalist and specialist backgrounds on the basis of their performance, publications, and prestige

as evaluated by peers.[86] Full use of their expertise is made through carefully designed questions and through carefully summarized comments.[87]

Others using the Delphi technique have noted further advantages. Human judgments are put on a par with or above quantitative data; barriers of time and geographical distance are overcome; information flow is equal to each participant; and specific, concise questions can be posed.[88] In addition, the researcher can act as a relatively unbiased filterer of opinions, weighing equally all views and keeping comments relevant to specific questions; ambiguous, poorly worded, or misunderstood questions can be cleared up and reworded for subsequent rounds.[89] Finally, the fallibility of the solitary expert, as in scenario writing, can be considerably reduced through the use of a group of experts.[90]

Numerous disadvantages of the Delphi method have also been noted, and Helmer himself is the first to mention them. He acknowledges the difficulty of inherently insufficient reliability, the tendency to produce self-fulfilling or self-defeating prophecies, the bias in the results from ambiguous questions, and the difficulty in assessing and utilizing expertise.[91] Helmer notes, however, that these criticisms apply equally as well to other forecasting methods. He also admits to flaws in his technique, including: instability of panel membership, lengthy time lapses between rounds, lack of substantive breadth or open-endedness of the questions, and an artificial consensus through the use of median and middle 50 percent responses.[92] Murray Turoff has expressed concern that the use of the methodology is increasing faster than it is being criticized; in particular, he sees dangers in the lack of assurance that scales will be interpreted similarly by respondents from different backgrounds, in the possibility

that dissenters will become disenchanted and drop out of the study, and in the chance of a biased sample because participants are unpaid and thus only volunteers take part in the study.[93]

Variations of the original Delphi format are common. Some Delphi studies start the first round with descriptions of external events--political, social, economic, and environmental--which are expected to take place in the future.[94] Others start with a blank piece of paper and ask participants to construct the future.[95] Still others have the experts rate their own expertise for each question, allowing for weighting of the responses.[96] Several others shorten the number of rounds to three or two without any loss in accuracy; in fact, Norman Dalkey, using Almanac-type questions, found that the median response from the second round was more accurate than the median response from either the third or the fourth rounds.[98]

Another variation is the increased importance given to the comments of all of the panelists. Starting with the first round, comments are elicited from everyone, regardless of whether or not their responses were outside of the middle 50 percent ranges.[98] Turoff is designing a computer conferencing system, based upon the Delphi approach, which will enable participants to carry on continuous, group communications through interactive, time-shared computer facilities. In this way, the Delphi method becomes more than a forecasting tool; it also becomes a communications tool for discussing pros and cons of policy issues.[99]

A final variation involves the selection of experts, particularly the decision as to who is an "expert." While Helmer insists that the composition of the panel of experts is crucial, several studies

have tested this contention and found that panels of experts of completely different compositions came to essentially the same conclusions.[100] Turoff uses "experts" to mean "informed people," people affected by the system as well as people who want to change it.[101] Juri Pill raises further doubts as to the definition of "expert opinion":

> Most of the uses of Delphi so far have been akin to a Brave New World: there is always the use of "experts", and when it is used thus on social questions, the information invariably becomes second-hand. This is not necessarily harmful, but the danger is certainly there of the loss of contact with the public. However, there seems to be no reason why one couldn't use the technique to elicit the opinions of mere people.[102]

In his study of communications services in the home, Michael Bedford used two interacting panels of experts, one of housewives and the other of communications experts.[103] Although differences in responses were generally minimal, the interaction of comments was informative. In all of these variations the definition of an expert is given a broader meaning.

For the purposes here, the intuitive approach to forecasting seems to withstand critical scrutiny better than other methodologies. The disadvantage of "genius forecasting," cited as a shortcoming of nonprofessional futurists, can be improved in the Delphi method through the panel of experts. The comprehensiveness of the normative methods can be maintained without the necessity of highly sophisticated techniques of mathematical analysis. Scenario writers and Delphi panelists can consider only the quantified data from trend predictions, and only the interactions of trends from models, which they judge to be

significant. Data which are incomplete, uncertain, or otherwise limited can be supplemented with intuitive observations. Most important, the political, social, economic, and environmental forces, often inadequately considered by other methods of exploratory forecasting, can be incorporated by the scenario writer or the Delphi forecaster into the structure of the intuitive approaches. Social consequences can be dealt with in the macro trends of scenario writers, and specific questions on social impacts can be part of a Delphi design. The combination of a Delphi forecast and a scenario appears to be the useful methodology for which the prudent prognosticator has been searching.

LIMITATIONS

But, caution lights are still flashing. There are more general limitations which accompany any method of forecasting. Equipped with an apparently accurate, complete, rational and secure methodology, the forecaster might be lulled into thinking that the troubles are over. Closer inspection of these assumptions, however, is needed.

Accuracy in controlled scientific experiments can be enhanced by isolating the phenomena from outside, environmental influences; however, accuracy in social predictions cannot be enhanced in this manner, because the phenomena are inseparable from outside, environmental influences. The only factor which can be judged is how well the information is used.[104] This does not necessarily correspond with getting the "right" answer; forecasters have occasionally stated the "right" answer without using the information correctly.[105] Forecasters

have values and opinions, including prejudices and biases, which may cause them to envision the future as they would like to see it, not as it probably will be. Furthermore, accuracy is hard to measure because it is difficult to estimate what the future would have been, had no forecast been made: prophesiers may be in the position of implementing their own forecasts, thus creating truly self-fulfilling prophecies.

Completeness is another slippery concept. Narrowed into their specialized areas, experts may be aware of related technology in their own field, but they can fail to see related technology in other fields--they can see the closer trees, but they have no perception of the more distant trees or the forest as a whole. Complete forecasts of technological changes need to take into consideration the complex interactions of convergent, complementary, technological developments.[106]

Rationality and security are the most illusory of these qualities. Forecasting is still a creative art; irrationality, elements of luck, uncertainty, and accidental discoveries, which are part of change in the "real" world, should be allowed for and included in the forecaster's methodology. Rational, cautious, secure methods, accepting the conservative assumption at each step of a forecast, tend to multiply their error and arrive at extreme understatements of the future.[107] Breadth and flexibility should be allowed for when forecasting the impacts of technological developments which produce their own demands, such as atomic energy, computers, and dry copying.[108] While forecasts of revolutionary change are made which are rejected by society at that time, it is more frequent that forecasters

lack the boldness and imagination necessary to foresee many of the breakthroughs which occur.[109]

So, duly cautioned about assumptions that any methodology can be accurate, complete, rational or secure, and prepared with a critical knowledge of current methodologies of technological forecasting, the prognosticator can proceed to examine previous forecasts and studies of educational telecommunications technology.

Chapter 3

CRITIQUE: PREVIOUS FORECASTS OF EDUCATIONAL TECHNOLOGY

(Hasn't Somebody Already Done That?)

To avoid needless duplication of effort and to improve upon any important limitations, previous forecasts and studies of educational telecommunications technology are reviewed and appraised here with the same critical eye exercised earlier. The reports are examined in sections titled:

National Academy of Engineering;

Lockheed Missile and Space Company;

Carnegie Commission on Higher Education;

Bell Canada;

Anastasio and J. S. Morgan;

R. P. Morgan, Singh, Anderson, and Greenberg.

Suggested improvements for a new forecast are made in a final section.

NATIONAL ACADEMY OF ENGINEERING

With the intention of learning something about the methodology of technology assessment, the U.S. House Committee on Science and Astronautics called upon the National Academy of Engineering to do some sample assessments, including one on teaching aid technology.[110] That this report is an assessment distinguishes it from the other reports which are forecasts. The difference between an assessment and

a forecast is often fuzzy, but Martin Jones of the Mitre Corporation has made one clear interpretation which puts a forecast as the initial part of an assessment.[111]

The assessment methodology developed by the National Academy of Engineering had seven steps:

(1) define and identify the subject matter,

(2) develop a data base for the technology,

(3) identify alternative strategies for implementation,

(4) identify parties affected by the technology,

(5) identify impacts of the technology upon the parties,

(6) assign a societal value to the impacts, and

(7) synthesize impacts into action alternatives.

In applying this methodology to teaching aid technology, the limits of the subject to be assessed were defined. Teaching aid technology was limited to instructional television (ITV) and computer-assisted instruction (CAI); education was limited to higher education. The subject matter was further limited to consideration of the trade-offs necessary between the desirable and undesirable consequences of the technology upon two problems--rising costs and student unrest.[112]

The second step was to develop a data base for the technology. Instructional television was described as a closed-circuit television system, supplemented with video-tape facilities;[113] computer-assisted instruction was described as an outgrowth of teaching machines and programmed learning.[114] Both types of technology were seen as facing barriers of cost and problems of social acceptance by students and faculty.[115]

Third in the procedure was the identification of alternative strategies for the implementation of the technology. Four strategies were identified as plausible alternatives for teaching aid technology:[116]

(1) no new funding, with survival on existing funding;

(2) no new funding, but consolidation of existing funds allows greater emphasis on teaching aid technology;

(3) new federal funding of $100,000,000 per year;

(4) new federal funding of $1,000,000,000 per year, and establishment of a new administrative agency.

In each of these alternatives, the key variable is funding.

Fourth was the identification of the parties affected by the technology. Alternative strategies for implementation of teaching aid technology will have different consequences for parties connected with education, parties with special interests, and parties unaware that this technology will have an impact upon them.[117]

Fifth was the identification of the impacts of the technology upon these parties, short-term technical impacts as well as long-term political, social, economic, and environmental impacts. A simple scale of favorable/unfavorable, likely/unlikely, and controllable/uncontrollable was used in their study to evaluate impacts related to higher education, students, faculty, and industry (see Figure 7). Controllable impacts were of interest because policy changes could make them more favorable and more likely.[118]

The sixth step was to assign a societal value, such as economic cost or social value, to each of the impacts which had been identified.[119]

FIGURE 7

NATIONAL ACADEMY OF ENGINEERING ASSESSMENT*

Impacts and characteristics of no new federal funding for teaching aid technology

Impacts	Characteristics	
	Primary	Further
Institutions of Higher Education:		
Increased cost	F̸LC	F̸LC
Improved instruction	FL̸C	FLC
Physical plant modification	FLC	FLC
Closer ties between schools	FL̸C	FLC̸
Destructuring of curriculum	FL̸C	FLC̸
Extended day, week, and year	FLC̸	?L?
Need for more TV channels	F̸LC	?L?
Standardization; centralization	FLC	FLC
Improved continuing education	FLC	FLC
Coping with poorly prepared students	FL̸C	FLC̸
Students:		
Impersonal education	F̸L̸C̸	F̸L̸C̸
Individualized instruction	FL̸C	FLC
Aid for minority-group students	FL̸C	FL̸C
Student-instructor relationship	FL̸C̸	FLC̸
Faculty:		
Modified role of instructor	FL̸C	FLC
New copyright protection	F̸LC	?L?
Industry:		
Industry-controlled education	FLC	?L?
Development of industries, products	FL̸C	?L?

Note: F = Favorable, F̸ = Unfavorable; L = Likely, L̸ = Unlikely; C = Controllable, C̸ = Uncontrollable; ? = Unknown.

*adapted from National Academy of Engineering, A Study of Technology Assessment, p. 44.

The seventh and final step was to compare the advantages and disadvantages of the valuated impacts, synthesizing them into action alternatives which were then ranked in order of plausible effectiveness. This is often considered the responsibility of legislators.[120]

Completing this procedure for teaching aid technology with the assumption of no new federal funding, the National Academy of Engineering's conclusions for instructional television and computer-assisted instruction are generally pessimistic. They forecast that, without more federal support, the rising costs cannot be reduced without a corresponding drop in quality of instruction; furthermore, student unrest will not necessarily decrease, but might even increase because of greater feelings of depersonalization.[121]

In summarizing their evaluation of the methodology of technology assessment, the National Academy of Engineering notes limitations in the accuracy, completeness, rationality and security of assessment methods. Accuracy is hindered by the lack of sociological data:

> in the experimental assessment of the utility of instructional television and computer-assisted instruction, sociological data were not available concerning the consequences of the possible realignment of the relative roles of education in the home, the school, and industry. Broad social and economic repercussions could result from such changes in the higher education system of the country.[122]

In addition, they note that inaccuracies have occurred in the time scales of previous forecasts due to unforeseen political, social, and economic events, such as war.[123] They suggest that accuracy would improve if every assessment were to contain a critical appraisal of its methodology.[124]

Completeness is limited by insufficient consideration of related technological developments in other fields.[125] Some of this narrowness of vision can occur in the approach chosen for the assessment, that is, whether it is problem-initiated or technology-initiated. Problem-initiated assessments identify social problems and then evaluate the feasibility of technology as part of the solution; however, technology-initiated assessments start with a new technology and then evaluate possible social impacts.[126] Technology-initiated assessments are often narrow and incomplete:

> cause-effect chain analysis does not lead easily to well-defined studies unless the study is modified by focusing the technology toward one or at most a few potential areas of social concern or social opportunity that might be significantly affected by the subject technology. If the selection of these areas is perceptive, the most significant future impacts (even second and higher-order impacts) of technology will be identified. The uncertainty in this approach is that in making the selection of problems to be addressed, important social and political impacts could be overlooked.[127]

They suggest that completeness would improve if the analysis of the impact of technology included measures of the "quality of life" as well as traditional technical or economic measures.[128]

Rationality and security confine the assessment; intuitive contributions are suggested as ways to expand these bounds. In their report, selection of assessment task force members is seen as analogous to the casting of characters in a play or movie: personal qualities of creativity, intuition, and imagination are necessary to play the role of a technology assessor.[129] Problem-initiated assessments need this as much as technology-initiated assessments:

> it is important in any successful technology assessment to bring to bear the opinions of creative, imaginative thinkers who, starting from a framework of logic and existing knowledge, can apply well-informed intuition to long-term forecasting.[130]

They suggest the Delphi methodology as a technique of forecasting which incorporates the necessary intuitive qualities.[131]

On appraisal, the National Academy of Engineering study, although not a forecast, comes to some conclusions about assessment methodology which are similar to conclusions drawn in Chapter 2 about forecasting methodology. Both forecasting and assessment methodologies require caution with respect to the accuracy, completeness, rationality and security of the techniques. Both need to consider important political, social, economic, and environmental forces. Both need a normative or problem-initiated approach. The suggestions for including these considerations are: perform a critical appraisal as part of the methdology, include measures of "quality of life," and use an intuitive forecasting methodology like Delphi.

The National Academy of Engineering report limits consideration of technology to instructional television and computer-assisted instruction, limits consideration of education to higher education, and limits consideration of social impacts only to cost and student unrest. In looking at a more complete range of technology, it is also necessary to include computer services and computerized library services. A more complete range of education would include much more than higher education. The necessity of including a more complete range of social impacts is seen by the choice of student unrest as a major impact, when now this appears to have faded as a major concern. The pessimistic conclusions may be a result of the assumption that no new federal funding would occur; alternative conclusions are imaginable under other assumptions.

LOCKHEED MISSILE AND SPACE COMPANY

Lockheed Missile and Space Company was contracted by the National Aeronautics and Space Administration (NASA) to predict demands for information transfer systems for the period 1970-1985.[132] These demands are listed as needs, using criteria of market potential, relative benefits to the nation, and functional requirements.[133] The technology includes all forms of electronic communications: telegraph, telephone, radio, television, and digital computer data.[134] Although not dealing specifically with educational technology, the transfer of information using technology has potential benefits for education.

The methodology used to arrive at the final list of thirty-one demands (see Figure 8) was assorted. Market potential was derived through combinations of expert predictions, GNP and population correlations, trend graphs, regression analyses, and computer market predictions. Benefits to the nation were analyzed by looking at the number of users and potentital beneficiaries; the availability and potential growth of the technology; the ease of implementing the service; the acceptability; and the social, economic, and scientific benefits.[135]

They conclude that the demands "most likely to succeed" are those relating to education and medicine for two reasons: (1) the large amounts of money which will be spent in these areas during 1975-1985, and (2) the trend toward egalitarian concerns which place education and health care services as rights to which everyone is

FIGURE 8

LOCKHEED FORECAST*

Demands for information transfer systems
for the period 1970-1985

1. Relay of medical diagnostic data and consultation
2. Relay of earth resources satellite data
3. Education programs for developing nations
4. Relay of weather balloon data
5. In-orbit flight testing
6. Relay of weather buoy data
7. Relay of support data for man in orbit
8. Relay of astronomy data from satellite
9. Relay of satellite control data
10. Education programs for pre-school students
11. Aircraft collision avoidance data
12. Education programs for grade school students
13. Education programs for adult students
14. Civil defense and emergency communications
15. United Nations teleconferencing
16. Centralization and relaying of employment records
17. Relay of weather satellite data
18. Relay of weather ships data
19. Relay tracking data for determining fish migration
20. Relay tracking data for determining animal migration
21. Relay of deep space exploration data
22. Relay of orbit assembly data
23. Education programs for ailing at home
24. Legislative teleconferencing
25. Political teleconferencing
26. Civil defense, emergency warning data transmission
27. Education programs for high school students
28. Education programs for criminal rehabilitation
29. Education programs for rural communities
30. Enroute air traffic control, commercial
31. Computational information services

Note: these are the relative rankings of these demands

*adapted from W. C. Sedlacek et al., Summary Report: Information Transfer Systems Requirement Study, p. 8.

entitled.[136] They further conclude that four types of networks will be necessary to satisfy the demands:

(1) information dissemination and broadcast--one-way information flow from a central terminal to outlying ones,

(2) data collection and distribution--information gathered from many sources and passed on to receiving terminals,

(3) inquiry and response--special information request terminals inquire of a large central repository which is a library of multi-purpose information,

(4) computational--similar to inquiry and response with additional time-shared facilities to calculate and compute data which are received.[137]

Of these networks, the one carrying the largest flow of information as well as the one satisfying most educational demands is predicted to be the information dissemination and broadcast network.[138]

They also recognize obstacles to the growth of information transfer systems which could arise in technological advancement, social acceptance, and government sponsorship. Technological research and development may need to design terminal equipment, cable television, video-tape equipment, and, in particular for education, editing and redistribution capabilities. Social acceptance may require careful study of the needs of the public. Finally, government sponsorship may be necessary for federal funding, favorable regulations, and the setting of national goals which emphasize these demands.[139]

In summary, they recommend the use of experimental satellites as testing grounds for the two most likely demands of education and

medicine, with an evaluation from the user's perspective being necessary to obtain meaningful results.[140]

An appraisal of the Lockheed Missile and Space Company's forecast must recognize the expected emphasis upon space technology which occurs in the report. Many of the demands forecast reflect this emphasis. Although the methodology did include examination of social acceptability and benefits, it is imaginable that social measures would be weighed differently under other assumptions about society. For example, if it were assumed that society would choose to reorder priorities such that high school, criminal, and rural education programs were given more importance than space programs, it can be imagined that this forecast of demands would change. Perhaps the use of methods of trend prediction and modeling in their forecast is the reason why alternative assumptions such as this are not considered.

A question might also be raised about the completeness of the conclusions of the report. Both the financial and the egalitarian trends which are foreseen for education and medicine might be more complex than is described. Both trends are influenced by a complex interaction of trade-offs of who provides how much support for which parties. For example, various levels of support by federal, state, or local governments for different socio-economic groups are possible in financial trends; in addition, various degrees of support by various social organizations for equal rights of different communities are also possible. Furthermore, the prediction that education will use primarily the information dissemination and broadcast network seems

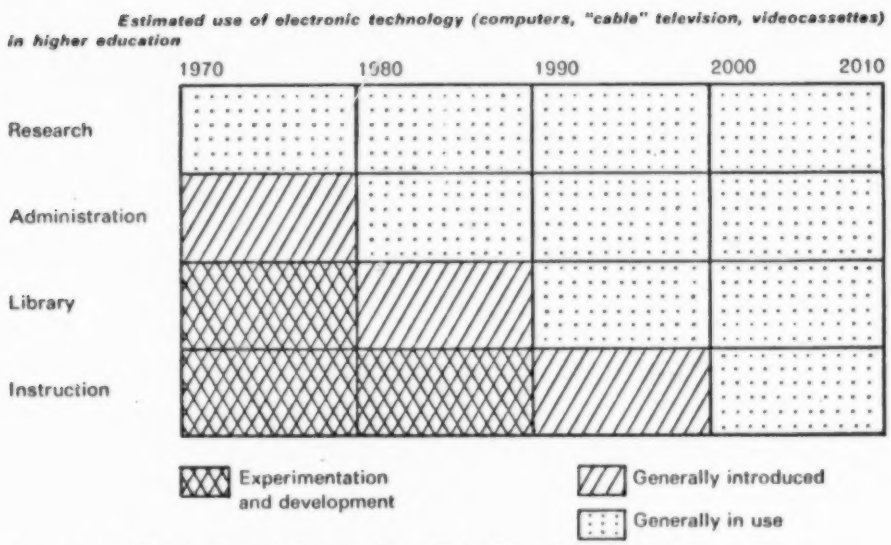
incomplete if educational institutions begin to make extensive use of computer-assisted instruction or time-shared computer facilities, thus making the use of other networks equally important.

Finally, it seems very important that they called attention to obstacles of social acceptance and government sponsorship, and to pilot studies which include an evaluation from the user's perspective.

CARNEGIE COMMISSION ON HIGHER EDUCATION

The Carnegie Commission on Higher Education predicts a fourth revolution in education as the technology of communications and data processing develops into a major research, administrative, instructional, and library tool.[141] Their report concentrates on the instructional, particularly formal instructional, possibilities of a complete range of new technology: microfilm, dry copying, film, multi-media classrooms, self-instruction units and laboratories, instructional radio, instructional television, and computer-assisted instruction.[142] Miniaturization, computerization, and proliferation of information also bring into the picture the expanding role of libraries as they incorporate technology to become information centers, learning-resource centers, and networks of communication and information.[143]

In compiling their own estimates of the future use of electronic technology in higher education (see Figure 9), the Carnegie Commission uses the results of previous studies by George Comstock and Jarrod Wilcox. Comstock, who surveyed the use of computers for instruction in California, found that they were most frequently used for data processing and computer science, followed by widespread use



SOURCE: Staff of the Carnegie Commission on Higher Education.

FIGURE 9

CARNEGIE COMMISSION FORECAST*

*from Carnegie Commission on Higher Education, The Fourth Revolution, p. 2.

as teacher's aids, in problem solving, and in research.[144] Wilcox concluded that "only those technologies well within the current state of the art are foreseen by faculty as destined for adoption within the next 15 years,"[145] but he observed that educational technologists were more optimistic than faculty in business and education, who themselves were more optimistic than faculty in the liberal and fine arts.[146] By the year 2000 the Carnegie Commission forecasts that instruction by educational technology may account for 10 to 20 percent of the instruction on campus and 80 percent or more of off-campus, post-secondary school instruction.[147] They also forecast improved diversity and variety of educational opportunities for the sick, handicapped, aged, prisoners, military members, and adults for compensatory and continuing education, as a result of informational technology.[148]

A large part of the report is devoted to an assessment of the possible impacts of educational technology upon students, faculty, and society in general. Coupled with this impact assessment are recommendations from the Carnegie Commission of actions to be taken by institutions of higher education or government, or both. These suggestions are made to encourage action now to hasten the development and implementation of educational technology.[149] For students, the impacts are seen as general improvement of quantity and quality of instruction as well as the "humanization" of higher education.[150] For faculty, the impacts may involve changes in their teaching style and material, but they will not necessarily create fears about job security.[151] Short-term costs are seen as increasing; long-term costs are seen as being less than conventional methods of instruction.[152]

Society in general may experience new attitudes toward education, such as who goes to school, what is taught, where education occurs, when education takes place, and why people take courses. Buildings and organizational structures may change; "regionally organized cooperative learning-technology centers" are suggested.[153] Recommendations are made that the role of government be to provide extensive funding for research and development; the role of industry be to develop and manufacture the instructional "hardware"; the role of nonprofit organizations and educational institutions be to design instructional "software."[154]

Boldness and imagination are certainly not lacking in this report from the Carnegie Commission:

> The year 2000 could also mark the completion of more than 25 years of concentrated effort toward the advancement of learning through instructional technology. At this point it should be feasible for teachers and students to contemplate the ultimate dream of all those who have given serious thought to the potentials of the new media--a national interconnection of independent information, communication, and instructional resources, with the combined capacity of making available to any student, anywhere in the country, at any time, learning from the total range of accumulated human knowledge.[155]

The Carnegie Commission on Higher Education, on appraisal, presents an accurate and complete listing of the full range of educational technology, and it roughly covers the possible impacts of the new technology upon higher education. Although limiting their attention to primarily instructional uses of the technology, they do give consideration to the other areas of research, administrative, and library uses. The source of their forecast of estimated usage of technology, however, is the staff of the Carnegie Commission on Higher Education, and the methodology which they used is not explained

in the report. It is at least a possibility that the chart was designed as much for aesthetic balance as for accuracy.

Their completeness is limited, quite naturally, because they deal with only higher education. The completeness of their impact assessment is questionable. Again, the impacts may be more complex than is envisioned; trade-offs may necessarily occur. It is conceivable that anti-technology crusaders will provide support for ideas from teachers that the new technology is a threat to them and for ideas from students that technology is dehumanizing. Moreover, attitudes of the federal government toward education may delay the funding of research and development programs for the new technology. Consequences for society in general could be probed further to find the point at which trade-offs would occur.

BELL CANADA

Frank Doyle and Daniel Goodwill of Bell Canada use the Delphi method to forecast the utilization levels of information systems technology in education, and, as a means of summarizing the results, they use a scenario of education in 1990.[156] They are looking at educational, electronic technology to see when it will be utilized and whether or not it will contribute to the learning process.[157] They attribute past failures of educational technology to cost and lack of social acceptance: costs of systems of dubious benefit have been very high, and there has been a hesitancy by people to accept unfamiliar technology, particularly when the technology has seemed to foster depersonalization and conformity.[158]

After examining other methodologies, Doyle and Goodwill decide upon a combined Delphi method and scenario. Trend prediction techniques are dismissed because they cannot account for rapidly changing and discontinuous values, they cannot extrapolate new and unfamiliar systems, and they rely so heavily upon macro trends that micro trends are neglected.[159] A three or four round Delphi, with emphasis upon the comments and opinions of the participants, appeals to them as a method effective in forming a consensus and in increasing accuracy of predictions.[160] The panel of experts which they assemble has diverse backgrounds:

> AV [audio-visual] experts, librarians, researchers in educational methods, researchers in computer applications for education, school administrators, educational administrators in government, educational consultants, graduate students, [and] teachers.[161]

These experts are asked to forecast three things:

(1) values held by people in the future,

(2) utilization levels of educational technology, and

(3) changes in the role of the teacher.[162]

The first conclusions are the magnitude, direction, and causes of changes in societal values:

traditionalism--significant decrease resulting from hippies, clothing fads, student demands, and religious liberalism;

hard work as a virtue--slight decrease as leisure-time increases cause a de-emphasis of work;

authoritarianism--slight decrease as permissiveness replaces more traditional discipline;

materialism--no net change because forces rejecting the "disposable, consumer-oriented society" are balanced by forces accepting the "rich, affluent, leisure society";

reward work as a virtue--slight increase as work becomes more relevant and self-fulfilling;

participation in decisionmaking--slight increase as industry and education spread out the decisionmaking process;

involvement in society--slight increase as mass culture, mass education, and mass communications flourish;

individualism--slight increase as mass education causes greater self-confidence and expressiveness;

acceptance of change--significant increase as seen in recent environmental and other concerns;

self-expression--significant increase as communication processes grow and develop.[163]

It is interesting to note that there are cultural differences between the Canadian and American participants in the responses which they gave to these values.[164]

The next conclusions are about the utilization levels for computer-assisted instruction (CAI), information retrieval television (IRTV), computerized library services (CLS), and terminal technology. Forecasts for each technology are made of utilization in primary, secondary, post-secondary, and home educational environments. Computer-assisted instruction is seen as requiring changes in student-teacher relationships; that is, students would control the learning process while teachers would be available to guide, suggest resources, stimulate motivation, and answer questions.[165] By 1976-1980, initial

(meaning about 20 percent) utilization is expected in secondary and higher education; by 1981-1985, utilization in these areas should be widespread (meaning about 55 percent) and utilization should be at the initial level for primary education; by 1986-1990, computer-assisted instruction should be widespread in all education. This particular pattern of development is foreseen because it is anticipated that higher education will be the first to have available the necessary finances for hardware and skills for software programming.[166] It is expected that school systems would be willing to pay more if they could be assured that the quality of their education would increase; moreover, it is anticipated that as the market of users increases, the per capita costs of the hardware and software will decrease.[167]

Information retrieval television is seen as being some form of coaxial distribution of learning materials from a central library to television or cassette receivers in individual classrooms.[168] By 1976-1980, it is expected to reach initial levels of utilization in all educational environments; by 1981-1985, utilization should be widespread and moving toward a national, interconnected network.[169] This assumes that the problems of finances, programming, and teacher resistance are ameliorated.[170]

Computerized library services are seen as part of large, organized networks for information retrieval. By 1976-1980, initial utilization is predicted for higher education; by 1981-1985, usage in higher education should be widespread with initial utilization in secondary education; by 1986-1990, secondary schools should be at widespread utilization levels and primary schools at initial levels;

by 1990-2000, all educational environments are expected to be using widespread computerized library services.[171] Integration of these systems will most likely occur initially by regions rather than nationally.[172]

Terminals are the technology which feeds input to and receives output from computerized, central storage facilities.[173] Terminals available in groups of teaching areas are forecast by 1976-1980 in higher education, by 1981-1985 in secondary education, and by 1986-1990 in primary education. Portable and individual terminals are envisioned after 1990. The location of terminals is anticipated as libraries, information-resource centers, teaching areas, and carrels, depending upon the type of educational environment.[174]

The final conclusions which are drawn relate to variations in the educational environment through new roles for teachers, chemical learning, and education in the home. Instead of performing the "traditional imparting of knowledge," the teacher would "encourage interaction and group learning" as well as be "a sympathetic resource at the student's demand."[175] Significant increases are seen in the number of para-professionals and student-teachers whose function would be to operate the technology. Although programmed instruction and computerized ability testing would aid the teacher, it is predicted that the student-teacher relationship will always be important.[176] Chemical learning through drugs, electronic links between brains and machines, controlled genetic reproduction, and learning aided by hypnosis are all seen as possible in this century but not widespread in their utilization until after 2000.[177] Major learning outside of the classroom is predicted. By 1976-1980, students in higher education

will be spending more time in smaller groups or at home as a result of educational technology; by 1981-1985, students in secondary education will be doing the same; by 1986-1990, outside learning should be widespread in secondary and higher education; by 1990-2000, primary education is expected to be brought into the home.[178]

Doyle and Goodwill summarize all of these conclusions in the form of a scenario of education in 1990, highlighted by the following predictions. Values will emphasize planning and participation to satisfy social needs, adopting innovations only after they have been thoroughly assessed. Values of individualism and innovation will encourage educational systems to constantly change methods, roles, concepts, curricula, and learning environments. Students will need to learn how to learn by machine. Widespread utilization of educational technology will be as follows: instructional television will offer diverse and varied titles from a central library, making use of lasers and holograms to increase information storage potential; computer-assisted instruction will be an integrated system with a simple language enabling complex questioning and unsupervised use; computerized library services will be a partially integrated system with regional data banks offering instant facsimile reproduction and hard copy of microfilm; and terminals in the home will be widespread as classrooms are replaced by open area, learning-resource centers. In many areas there will be backlash movements urging a return to interpersonal learning, as opposed to the new "synthetic" learning.[179]

On appraisal the choice by Doyle and Goodwill of a combined Delphi and scenario methodology is appropriate when the subject area

being forecast is educational technology. As the needs and goals of education are very hazily defined, and as political, social, economic, and environmental forces are very important factors in education, there is good reason to use a method of forecasting which engages the intuitive judgements of a diverse group of people. The Bell Canada panel included a wide range of educators and communications technologists, although it did not include people with main interests in other areas. The inclusion of a forecast of values is an important addition to the Delphi methodology, because the values and opinions of people in the future will determine, to some extent, the usage of educational technology.

Although their coverage of the range of technology is complete, their coverage of educational environments is limited to primary, secondary, higher, and home education. This leaves out the consideration of early childhood education, vocational and technical education, adult and continuing education, and special education categories. By excluding these categories, they have chosen to give only a partial picture of education in the future. Also, the utilization of technology is never clearly defined: does it mean the percentage of schools using technology, or the percentage of instructional materials using technology, or some other measure of utilization?

Finally, the impacts of the political, social, economic, and environmental forces on the technology are hardly considered. The generalized values which were forecast seem obvious at first glance, but they may have more subtle consequences for the utilization of technology. For example, the materialism and increased participation

in decision-making by people might be cause for an increased trend toward accountability and productivity measures in educational technology. Or, taking another example, the value of individualism may cause criticisms of standardized programming in educational technology. In either case, the interrelationship of values and technology is incompletely explored in the Bell Canada forecast.

ANASTASIO AND J. S. MORGAN

Ernest Anastasio and Judith Morgan undertook an investigation sponsored by the National Science Foundation of factors which have inhibited a more widespread use of computers for instruction. Like Bell Canada they use the Delphi methodology and a diverse panel of experts: educational practitioners, theoreticians, hardware specialists, software specialists, evaluators of barriers to acceptance, and evaluators of actions to increase acceptance.[180]

They note six categories of factors which are thought to have inhibited computer-assisted instruction:

(1) lack of interest, incentives, and responsibility for the production and distribution of instructional materials;

(2) no proof of effectiveness of computer-assisted instruction in improved learning;

(3) insufficient psychological research on the learning process and its implications for computer-assisted instruction;

(4) ineffective planning and training to counter the fears held by teachers;

(5) incomplete accounting of necessary costs;

(6) inadequate research and development of technical design features of terminals and programs.[181]

Based upon these opinions of inhibiting factors, they offer recommendations for encouraging the research, development, and implementation of computer-assisted instruction.[182]

The appraisal of their study can be brief. Although not a forecast, it was included because it used the Delphi methodology. The title outlines the limitations. It is a study of the factors which have inhibited further use of computer-assisted instruction; it deals with only one type of technology, and it is unspecific about the categories of education with which it is concerned. Also the list of inhibiting factors is incomplete--what about the political impact of copyright problems for authors of computerized programs?

R. P. MORGAN, SINGH, ANDERSON, AND GREENBERG

Robert Morgan, Jai Singh, Barry Anderson, and Edward Greenberg, in work supported by the National Aeronautics and Space Administration, have estimated utilization ranges of educational telecommunications services for 1975 and 1985. Starting from background studies of technology and media, and keeping in mind the political, social, economic, and technological factors, they make "educated guesses" of possible utilization ranges.[183] In addition, they estimate what portion of these utilization ranges is likely to use satellite-based service[184] (see Figure 10). They divide educational telecommunications services into four categories: instructional television, computer-aided

FIGURE 10

MORGAN, SINGH, ANDERSON, AND GREENBERG FORECAST*

	SERVICE	PERCENTAGE UTILIZATION 1975 ELEMENTARY ED.	1975 SECONDARY ED.	1975 HIGHER EDUCATION	PERCENTAGE UTILIZATION 1985 ELEMENTARY ED.	1985 SECONDARY EDUCATION	1985 HIGHER EDUCATION	PRIMARY ROLES FOR SATELLITES	PERCENT OF THE POTENTIAL USER INSTITUTIONAL POPULATION LIKELY TO MAKE USE OF SATELLITE-BASED SERVICES: ELEMENTARY EDUCATION	SECONDARY EDUCATION	HIGHER EDUCATION
	INSTRUCTIONAL TELEVISION [ITV]#	3 - 6	4 - 8	5 - 10	4 - 20	4 - 25	5 - 20	DIRECT DELIVERY TO SCHOOLS; TO BROADCAST STATIONS, AND ITFS AND CABLE HEADENDS FOR FURTHER REDISTRIBUTION.	40 - 90	40 - 90	20 - 50
	COMPUTER-AIDED INSTRUCTION [CAI]#	0.1 - 2	0.3 - 2	1 - 3	1 - 10	5 - 20	5 - 20	DELIVERY OF CAI TO SMALL, REMOTE INSTITUTIONS, PARTICULARLY THOSE 70-80 MILES OR MORE AWAY FROM A MAJOR METROPOLITAN AREA.	15 - 30	15 - 30	5 - 10
COMPUTING RESOURCES	MULTI-ACCESS INTERACTIVE COMPUTING	4 - 10	5 - 12	15 - 30	8 - 20	15 - 50	50 - 80	DELIVERY OF INTERACTIVE COMPUTING TO REMOTE INSTITUTIONS FOR THE PURPOSES OF PROBLEM SOLVING, EIS, ETC.	15 - 30	15 - 30	10 - 20
COMPUTING RESOURCES	BATCH PROCESSING [Including Remote-Batch]*	7 - 35	30 - 50	65 - 75	15 - 70	50 - 80	80 - 100	DELIVERY OF RAW COMPUTING POWER TO SMALL, ISOLATED, AND REMOTE INSTITUTIONS FOR INSTRUCTION, ADMINISTRATIVE DATA PROCESSING ETC.	20 - 30	20 - 30	2 - 5
COMPUTING RESOURCES	COMPUTER INTERCONNECTION*	0†	0†	0.8 - 2	0†	5 - 10	10 - 20	DELIVERY OF RAW COMPUTING POWER TO SMALL, AND REMOTE INSTITUTIONS FOR INSTRUCTION, ADMINISTRATIVE DATA PROCESSING, ETC	40-80 % of Regional Computing Networks; 60 - 80 % of Campus Computing Facilities (Higher Education)		
INFORMATION RESOURCE SHARING	INTERLIBRARY COM. --. TWX, FACSIMILE*	0	0+	10 - 20	0.5 - 1	2 - 5	20 - 40	FOR BIBLIOGRAPHIC SEARCH, INTER-LIBRARY LOANS, ETC.	5 - 10	25 - 40	40 - 70
INFORMATION RESOURCE SHARING	AUTOMATED REMOTE INFO. RETRIEVAL*	0	0+	0.8 - 2	0	0+ - .5	2 - 5	FOR REMOTE INFORMATION RETRIEVAL, AUTOMATED BIBLIOGRAPHIC SEARCH FROM SPECIALIZED CENTERS.	0	1 - 10	40 - 70
INFORMATION RESOURCE SHARING	TELECONFERENCING* [Long Distance]	0+	0+	4 - 6	0.5 -2	0.5- 2	6 - 10	FOR ACCESS TO SPECIALISTS IN DISTANT AREAS	3 - 10	3 - 10	10 - 30

Percentage Expressed in Terms of Time Spent By Student in Classroom.
* Percentage of Total Educational Institutions having This Capability.
† Interconnection Among Centralized Computing Networks May Develop during 1975+.

*from Morgan et al., Satellites for U.S. Education, p. 14.

instruction, computing resources (excluding computer-aided instruction), and information resource sharing. They make estimates for three levels of education: elementary, secondary, and higher.[185]

Morgan et al. recognize some of the limitations of their forecast. Estimates for vocational, special, and continuing education, and estimates for delivery to homes and learning centers, which are omitted from their report, will be part of their future work.[186] For some of their categories of technology, more detailed information on utilization, such as time actually used and information channel capacity required, is yet to be developed.[187] They expect their first, rough estimates to be revised after analysis and feedback from educational users and administrators; furthermore, the estimates will be affected by an analysis of the interrelated impacts of utilization levels upon education and of education upon utilization levels.[188]

On appraisal, their study is unclear at points. Utilization of instructional television and computer-aided instruction is expressed in terms of the percentage of time spent by the student in the classroom, while utilization of computing resources and information resource sharing is expressed as the percentage of total educational institutions having these capabilities. It is confusing and perhaps misleading to compare these different measures of utilization in the same graph. Also, it is unclear whether the forecast of satellite use is for 1975 or 1985, or both. Finally, the precision of the results is questionable. For example, is it really possible to find a basis for support of the difference in utilization percentages of 0.2% between computer-aided instruction for elementary and secondary education in 1975?

Precision of results is often mistakenly interpreted to mean greater accuracy of the results.[189]

SUGGESTED IMPROVEMENTS

In all of the previous studies of educational technology there are none which include a complete consideration of the full range of technology in the full range of educational environments. The National Academy of Engineering study is limited to instructional television and computer-assisted instruction in higher education; the Lockheed report considers only information broadcast and dissemination capabilities for educational technology and neglects higher education; the Carnegie Commission report considers a full range of technology, but only for higher education; the Bell Canada forecast also considers the complete range of technology, but only for education at primary, secondary, and higher levels; the Anastasio and Morgan study is limited to computer-assisted instruction in unspecified educational environments; and the Morgan et al. forecast considers a full range of technology for only primary, secondary, and higher education. In general, these studies do not include education other than primary, secondary, and higher education--they do not consider the educational uses of technology in early childhood, vocational and technical, adult and continuing, and special education. In forecasting educational technology, it seems important to include these other environments which may be an important part of education in the future. This would also mean consideration of education in public institutions, private institutions, and home environments. A diagram of the complete

matrix of possibilities for technology, education, and institutions is shown in Figure 11.

In all of the previous studies of educational technology there are none which consider completely the complex interactions of technology and political, social, economic, and environmental forces. The National Academy of Engineering study investigates only costs and student unrest; the Lockheed report mentions only that such considerations will need to be dealt with in the future; the Carnegie Commission report does not cover the complexities and trade-offs which are involved; the Bell Canada forecast neglects to consider the impact of the values which they have forecast upon educational technology; the Anastasio and Morgan study is incomplete, notably for political impacts; and the Morgan et al. forecast has left the considerations of these factors for future work--of which this thesis is a part. A complete consideration of the complex interactions of political, social, and economic values with technology seems imperative to understand the total scope of the development and use of educational technology. Suggested areas of consideration include: control of education, privacy issues, copyright issues, financing of education, accountability and productivity issues, equalization of opportunities, use of technology to supplement or substitute for the teacher, psychological fears, availability of education, nature of education, and goals of education (curriculum, certification, custody). The use of technology will cause changes in these values; the existence of these values will cause changes in the utilization of technology in education.

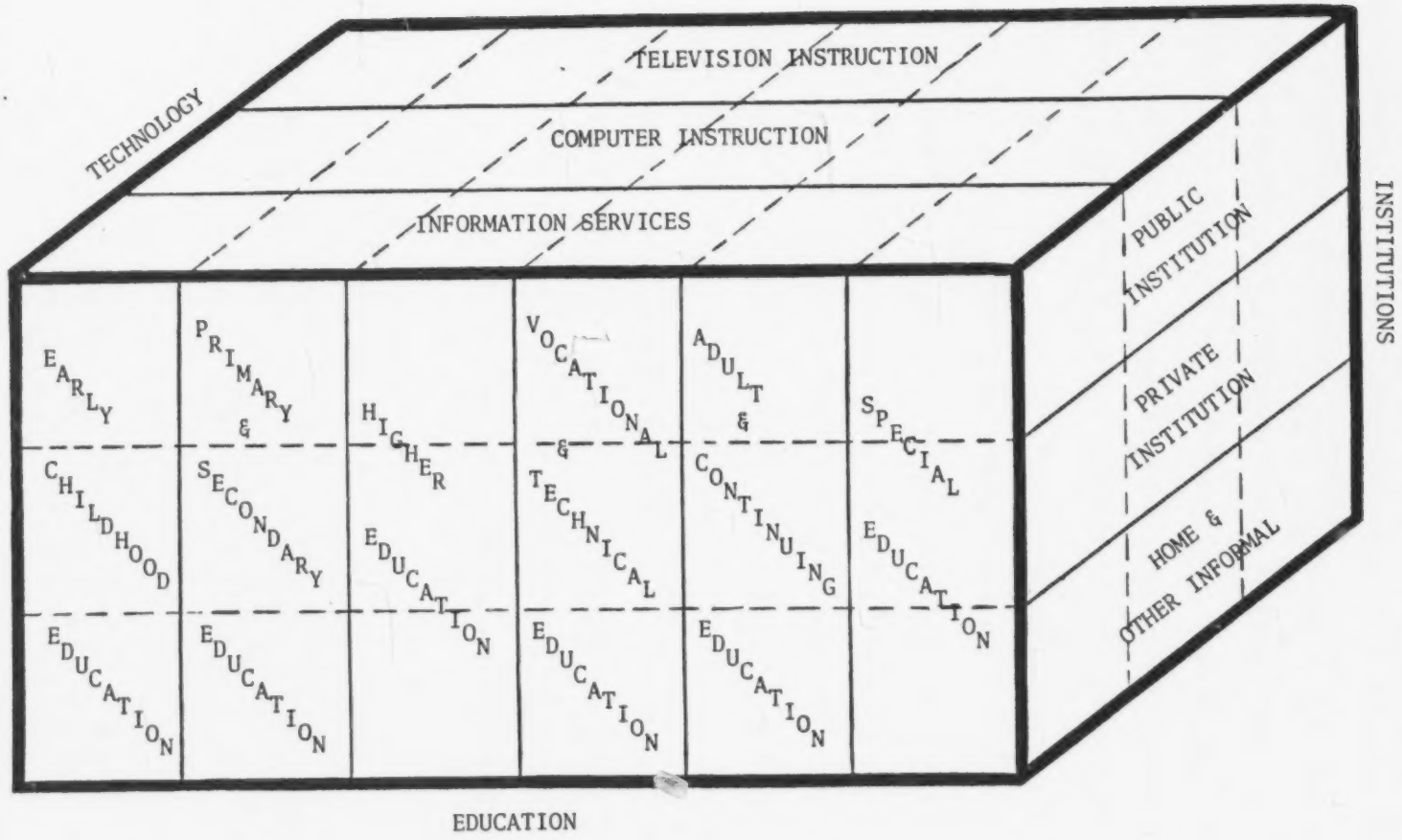


FIGURE 11

MATRIX OF TECHNOLOGY, EDUCATION, AND INSTITUTIONS

Only three of the previous forecasts of educational technology predict some sort of utilization levels: the Carnegie Commission, Bell Canada, and Morgan et al. None use their methodology to predict organizational structures, those structures which determine the delivery and software supply systems. The fact that educational technology exists in the future means little unless it is accompanied by some indication of its utilization and the organizational structures which are part of its operation.

Thus, an improved forecast would include predictions of the potential utilization and social impacts (including organizational structures) of educational technology. In attempting to follow-up the Morgan et al. forecast, educational technology would include those types of telecommunications technology to be used in large-scale educational systems--television instructic computer instruction, and information services. Hence, the explicitly stated problem for this thesis is to forecast the potential utilization and social impacts of large-scale, educational telecommunications technology. The definitions used follow in Chapter 4.

Chapter 4

DEFINITIONS

(So What Are You Talking About?)

The task at this point is to define the terms used in a forecast of educational technology. The definitions should be broad and flexible to allow for a wide variety of "futuribles," but they will necessarily involve certain limitations and assumptions. Considered for the Delphi forecast in this thesis are definitions of educational technology, educational environments, utilization levels, and social impacts.

EDUCATIONAL TECHNOLOGY

Educational technology is limited to only telecommunications technology which could be used in large-scale networks of delivery and software supply systems. Although some of the technology defined here could be used individually or on a small scale, the emphasis is upon usage in large-scale systems. The three types of large-scale educational telecommunications technology are:

(1) television instruction--programming of an educational value which may be viewed on television sets by either individuals or groups. Examples might include commercial or noncommercial broadcast television, closed-circuit television, community cable television, videotape recording, or videocassettes.

(2) computer instruction--programming of an educational value which is guided by a computer and visually displayed on a terminal device. These programs would generally involve two-way interaction and would vary in content and pace according to the learning ability of each individual student. Examples might include computer-assisted instruction, computer-based instruction, or computer-managed instruction.

(3) information services--electronic access to information resources available from interconnected networks of libraries or computer facilities, or both. Examples might include large-scale microfilming or audio-visual centers, computerized library systems, data banks of information, time-shared computer facilities, management information systems, or automated data processing services.

EDUCATIONAL ENVIRONMENTS

Educational environments are limited to six categories of education and three types of educational institutions. The assumption is made that the conclusions for each category of education or type of institution will be sufficiently broad to be accurate for any specific examples in each case. The six categories of education are:

(1) early childhood education--all forms of education prior to formal schooling, including programming aimed at parents and teachers to aid them in teaching children. Examples might include nursery schools, pre-schools, day care centers, television programs like "Sesame Street" and "Electric Company,"

elementary exercises or games guided by a computer, data banks of information about students, or access to library resources which would help teachers to improve their techniques.

(2) primary and secondary education--what could be considered as elementary, junior high, and high school education from grades Kindergarten through twelve. Examples might include state school districts, parochial schools, private preparatory schools, or television and computer programs which could be delivered in a variety of ways to homes or community centers.

(3) higher education--all forms of post-secondary education attempting to provide a liberal arts or professional educational background. Examples might include junior or community colleges, state colleges or universities, private colleges or universities, "open universities," "universities without walls," home correspondence courses, or access to library resources from homes.

(4) vocational and technical education--all forms of post-secondary education designed to train someone in a particular vocation, skill, or trade.* Examples might include state training schools, community centers, industrial training institutes, office skills schools, craft teaching centers, or home computer programming courses.

(5) adult and continuing education--compensatory education for those who missed opportunities during their formal schooling, enrichment courses for those who want to supplement or continue their education in particular areas, or continuing professional education for those who want to keep

*Note that this definition excludes vocational education at the high school level.

up with current discoveries or developments in their occupations. Examples might include night courses from colleges or universities, continuing professional education courses, or home and office access to library and computing resources.

(6) special education--specially designed education for particular interest groups such as the elderly, the handicapped, minority racial groups, religious or ethnic groups, cultural groups, prisoners, and other institutionalized people. Examples might include programming in hospitals, prisons, churches, retirement community centers, ghetto community centers, or television and computer terminals in the rooms of disabled people. (This is not the most common definition of special education. As used here it includes a wide variety of possible educational opportunities not included in the other categories.)

In each of these categories, examples have been given of education occurring in three types of institutions:

(1) public institutions,

(2) private institutions, and

(3) home and other informal environments.

UTILIZATION LEVELS

Utilization levels are limited by asking for a forecast of the percentage of locations or institutions in which technology is used in some aspect of the educational process. This means any use, no matter how slight or infrequent. The assumption is made that once the technology is installed in a location, the usage will increase,

provided that programming is available. The definition of the educational process is left open for interpretation as any kind of formal or informal learning experience. The percentage of locations is associated with a key word describing utilization as follows:

0%: no utilization,

1 - 19%: initial utilization,

20 - 39%: developmental utilization,

40 - 59%: moderate utilization,

60 - 79%: heavy utilization,

80 - 99%: widespread utilization.

This definition of utilization includes neither a measure of the amount of time spent using technology, nor a measure of the amount of instruction available which uses technology. Location means any building or structure in which technology could be placed and possibly used for education of people in a given category of education. For example, homes with elderly people and no pre-school age children would count as possible locations for special education but not as possible locations for early childhood education.

SOCIAL IMPACTS

Social impacts are limited to two basic types--organizational structures and values. Organizational structures are defined for both large-scale delivery systems and large-scale software supply systems. Large-scale delivery systems are networks organized for the distribution of television instruction, computer instruction, and information serivces; large-scale software supply systems are networks organized for the production and storage of television programs, computer

programs, and information services. Important aspects to forecast include organization, control, finances, distribution methods, access schedules, and cost of software.

Values are defined as attitudes and opinions. They are limited here to those expected to be held by people in 1990, and include a variety of political, social, and economic viewpoints. Trade-offs are often involved in specific values. It is assumed that the degree to which the technology has been utilized in various areas of education will determine, to some extent, the values which people hold; just as the values which they hold will determine, to some extent, the success of the utilization of the technology.

Chapter 5

DESIGN

(So What Is Your Approach?)

Having constructed a critique of methods of forecasting and noticed characteristics of the better approaches; having critically examined previous forecasts and studies of educational telecommunications technology and gleaned a few suggestions for improvement; having carefully prepared definitions of the terms to be used; one is now ready to design and execute the forecast for which this preparation has been done. The methodology chosen here is basically the Delphi technique with a scenario used to express the results. The development of the approach is described in the following sections: selection of experts, format, round one, and round two.

SELECTION OF EXPERTS

Using a broad interpretation of what constitutes an expert, names of possible participants in three areas of expertise were collected: those with interests in education, those with interests in communications technology, and those with interests in a wide variety of other areas. A list of these names was compiled in a brainstorming session starting with lists of participants from telecommunications technology conferences, authors of educational technology studies, teachers, professors, administrators in both government

and education, businessmen and consultants, students, and "average" people. A total of 123 names was assembled, including twenty-four names chosen randomly from various state school district directories.

Each of these possible participants was sent a letter inviting their participation, explaining the nature and purpose of the study, and assuring anonymity of their responses and comments. Enclosed with this letter was a copy of Round One of the study.

At this point the selection of the panel was done by the experts themselves. Some chose not to reply at all; some objected to the nature of Delphi studies as means of forecasting; some just didn't have the time to spend. Forty-nine participants chose to respond to Round One. Due to difficulties encountered by ten of these participants, thirty-nine participants who responded to both Round One and Round Two compose the final list of panelists for the study. Based upon typical response rates to Delphi studies,[190] thirty-nine final participants is about what could be expected. Those experts who gave permission to use their names in the final report are listed in the Appendix.

Thirty out of eighty-nine education or communications experts responded to both rounds. Nine out of thirty-four experts in other areas responded to both rounds, including only two responses from the twenty-four, randomly chosen educators. The original attempt to divide participants into the three categories of expertise was thwarted. After seeing the comments of many of those who returned Round One, it was obvious that there would be difficulties in sorting the participants into categories according to interests. Many had overlapping interests in education, communications technology, and various other areas.

Hence, the decision was made to pool all of the responses into one group, trying at the same time to bring out the diversity and differences of opinion which exist among the experts in different fields.

FORMAT

To gain the interest of busy experts and encourage them to participate in a Delphi study on educational technology, an attempt was made to design a format which was different from normal, whatever that is. One difference was in the organization of the material. The booklets for Round One and Round Two were bound with plastic, multi-ring binders and manila covers. They were printed on both sides of the pages--participants would go through the booklet once filling in the front side of the pages, then flip the booklet over, and go through it again filling in the back side of the pages. This was done to enable panelists to refer back to forecasts which they had made earlier, enabling consistency in their predictions, by merely flipping the booklet over.

Another difference was in the procedure used to forecast utilization and social impacts, which was explained in the Round One booklet as follows:

> While everyone is intrigued by what kind of world will exist in the future, no one has succeeded, as yet, in breaking the time barrier and going forward into the future. Only the science fiction writers with their hypothetical time machines have postulated such an idea. For the purpose of mentally exploring the future of education, we would like to ask you to imagine yourself sitting in a time machine which has been specifically programmed to allow you to view education in the future. You might picture yourself sitting in a large, comfortable easy chair with special controls which enable you to move through time.

> As with most journeys to new and different places, there may be a language problem. In order to assure maximum communication, we would like to ask you to familiarize yourself with some terms which will be used....

The definitions of educational technology and educational environments then followed. Participants were encouraged to relax and be comfortable for this "journey into the future." The intention was to encourage creative, imaginative, intuitive forecasts.

ROUND ONE

Imagining that they were observing technology and education in the future, the experts were asked to check percentages and numbers which described what they were observing. Their itinerary, or order of observations, was intended to take 50 minutes, as follows:

15 minutes in the year 1980 to observe the levels of utilization of each technology in each category of education;

15 minutes in the year 1990 to observe the levels of utilization of each technology in each category of education;

10 minutes in the year 1990 to observe the social impacts related to the organizational structures of large-scale delivery systems and software supply systems;

10 minutes in the year 1990 to observe the social impacts or consequences of particular values and opinions held by people in the future.

In many cases, much more than an hour was spent in checking responses and making well-thought-out comments. Although not intended, this extra effort was certainly appreciated.

Utilization levels were the subject of forecasts in both 1980 and 1990 so that an idea of the rate of growth in utilization could be determined. Aspects of organization, control, and finances were included for both the organizational structures of delivery systems and software supply systems so that a comparison of these could be made. As an aid to imagining what the values and opinions of people in 1990 will be, participants were asked to answer the value statements as if they were conducting a public opinion poll of people in the future. They were asked to determine the degree of acceptance or rejection of each value statement by the greatest number of people in 1990, and then to circle the most appropriate number on this scale:

1	2	3	4	5	6	7
strong rejection	moderate rejection	slight rejection	neutral	slight acceptance	moderate acceptance	strong acceptance

It was recognized that many of the value statements might be meaningless or outdated by 1990, but the intention of the forecast of values was also to get an idea of how these values might be changing.

At the end of each part of the "trip," all panelists were asked to justify the estimates which they observed, trying to think of factors or conditions which could have caused the utilization levels, organizational structures, or values to occur. These comments were requested from all participants, regardless of what the particular responses happened to be. On the final page, comments were welcomed on the phrasing or content of the questions, the format or scope of the study, and any other topics which had been slighted or neglected. All of the participants contributed many thoughtful comments, thus adding a great deal to the content of the forecast.

ROUND TWO

So that continuity and interest could be maintained, Round Two was mailed within eight weeks of the mailing of Round One. Round Two, the final one, was mailed to all forty-nine of the panelists who returned Round One, even though seven of them had returned the first round too late to have their data analyzed and fed back in this round.

Round Two presented the median and middle 50 percent of the responses for each question from Round One as well as a summary of the comments of the participants. After reviewing these responses and comments, each panelist was given the opportunity to reconsider his or her original responses and arrive at final estimates of the utilization and social impacts of educational technology. As there were no "right" answers, panelists were free to change their estimates in either direction, depending on how they felt at that time. Comments on why they changed any of their answers were requested.

In order to shorten the time spent participating in Round Two, the forecast of utilization levels in 1980 was eliminated. This seemed logical because the estimates of utilization in 1990 were consistently around 20 percent higher than those in 1980, and there was no reason to expect that relationship to change in a second round. This had the further advantage of making all of the estimates for Round Two in the year 1990.

The revised itinerary was again intended to take 50 minutes, as follows:

20 minutes reading the summarized comments from the other participants in Round One;

10 minutes to review and change any estimates of utilization levels of each technology in each category of education;

10 minutes to review and change any estimates of the social impacts of organizational structures of large-scale delivery systems and software supply systems;

10 minutes to review and change any estimates of the social impacts of values and opinions of people in the future.

Panelists indicated that this was a more accurate time allocation.

An attempt was made in the comment section to show the diversity and differences of opinions, some of which were conflicting. Participants were asked to scribble notes in the margins next to comments with which they either strongly agreed or strongly disagreed. Misunderstandings about utilization levels were aided by further explanation; in addition, unclear and ambiguous value statements were further explained or reworded and marked with an asterisk (*). Panelists were asked to sign a release form giving permission to list their name in this study.

Chapter 6

RESULTS

(So What Did You Find Out?)

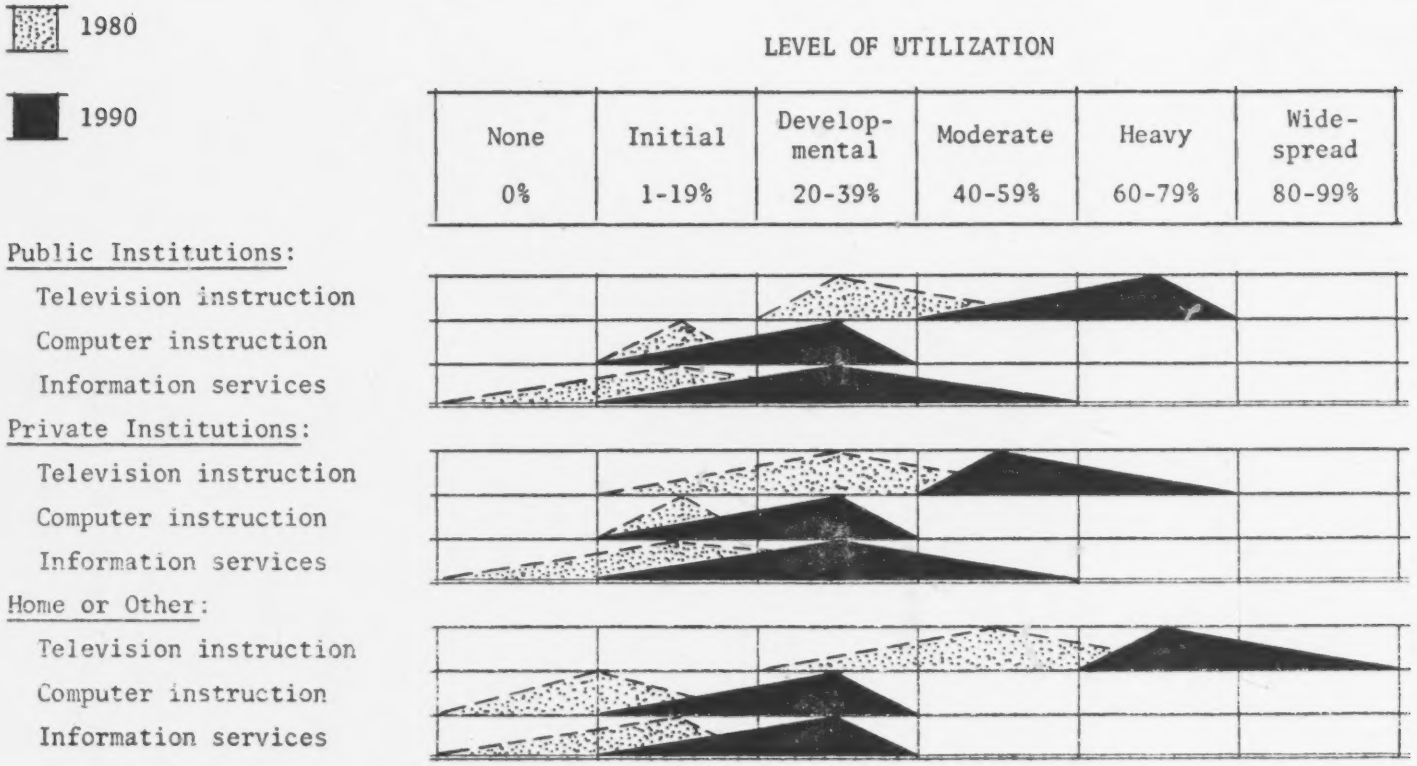
The results of this forecast are tripartite. One part displays graphically the final responses of the thirty-nine experts. A second part summarizes the comments of the experts. The third part describes, in the form of a scenario, one possible future of large-scale telecommunications technology in education. The events in the scenario represent the conclusions from the graphs and the conclusions from the summarized comments combined with the judgement of the author as to the relative importance of the various events.

GRAPHIC RESPONSES

The responses for utilization levels are shown in six separate graphs according to the categories of education--early childhood, primary and secondary, higher, vocational and technical, adult and continuing, and special education (see Figures 12A - 12F). The responses for the social impacts relating to organizational structures are shown in two graphs--one for large-scale delivery systems and one for large-scale software supply systems (see Figures 13A and 13B). The responses for the social impacts relating to values and opinions are shown in one graph (see Figure 14, pages 81-84).

FIGURE 12A

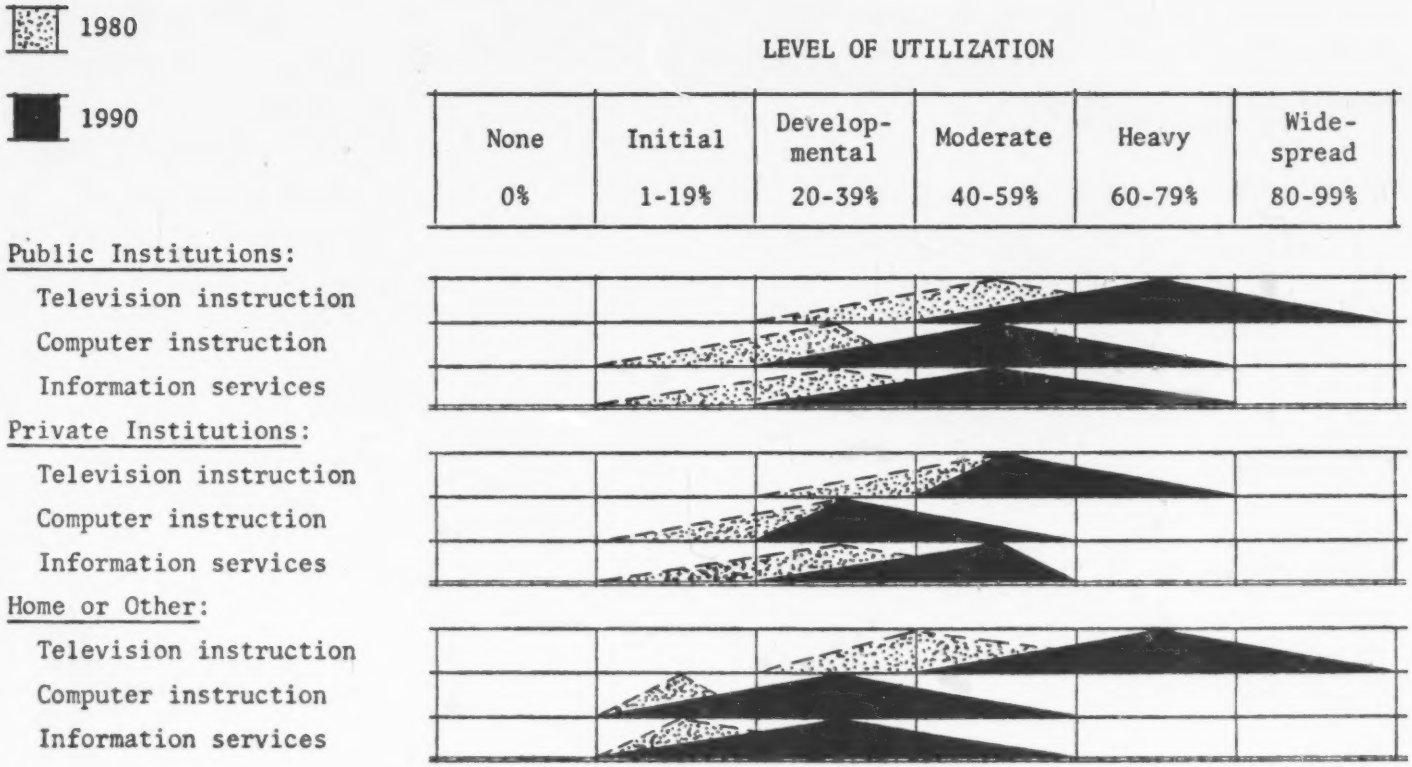
UTILIZATION OF TECHNOLOGY IN EARLY CHILDHOOD EDUCATION*



*The triangle represents the middle 50 percent of the responses, the peak being the median response.

FIGURE 12B

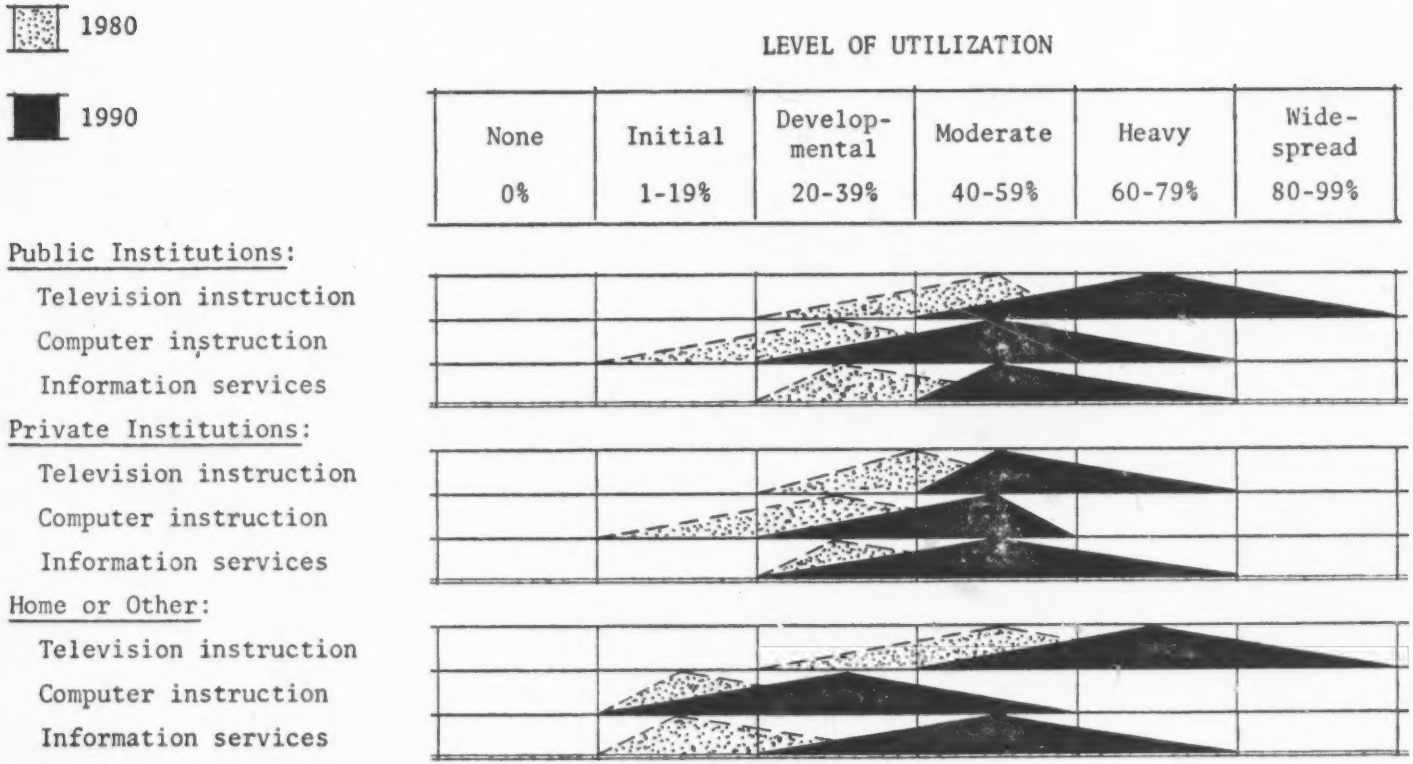
UTILIZATION OF TECHNOLOGY IN PRIMARY AND SECONDARY EDUCATION*



*The triangle represents the middle 50 percent of the responses, the peak being the median response.

FIGURE 12C

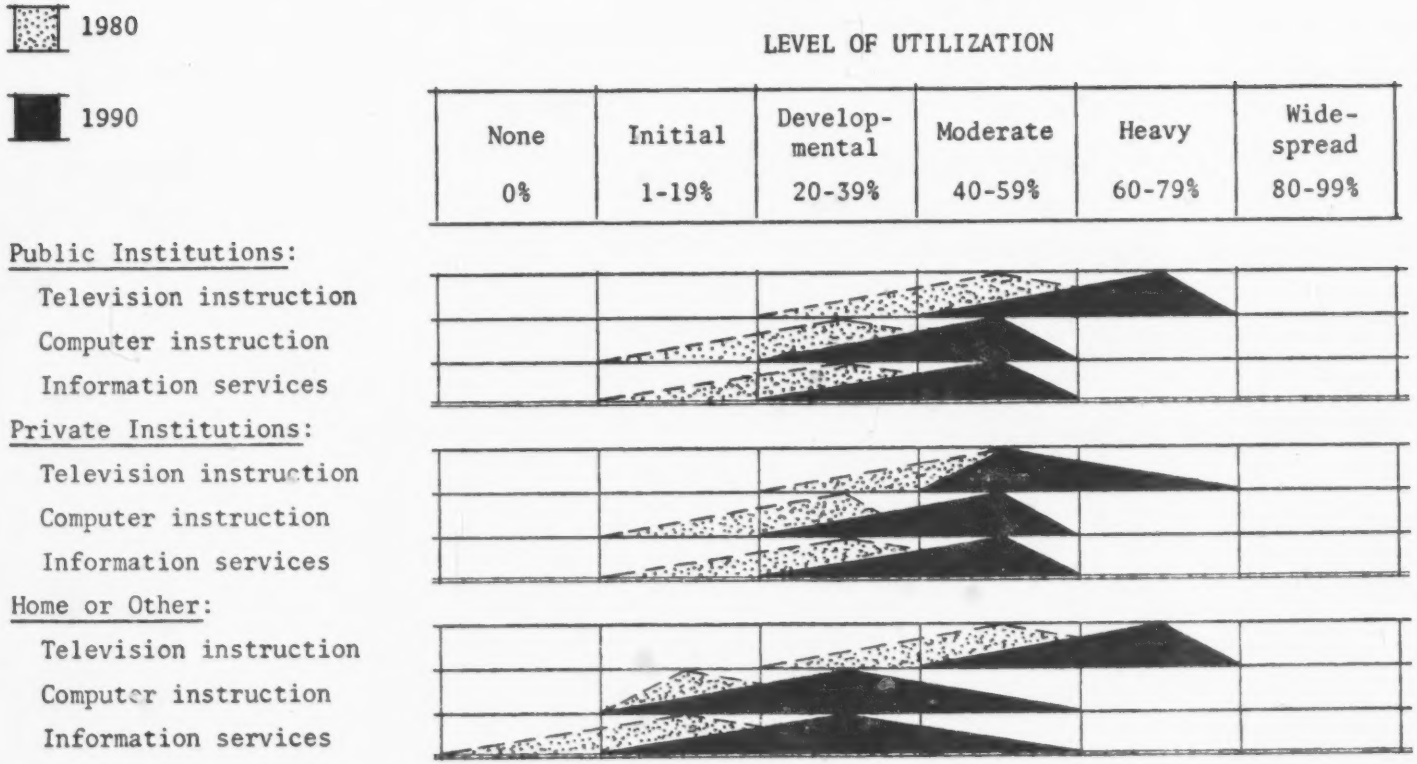
UTILIZATION OF TECHNOLOGY IN HIGHER EDUCATION*



*The triangle represents the middle 50 percent of the responses, the peak being the median response.

FIGURE 12D

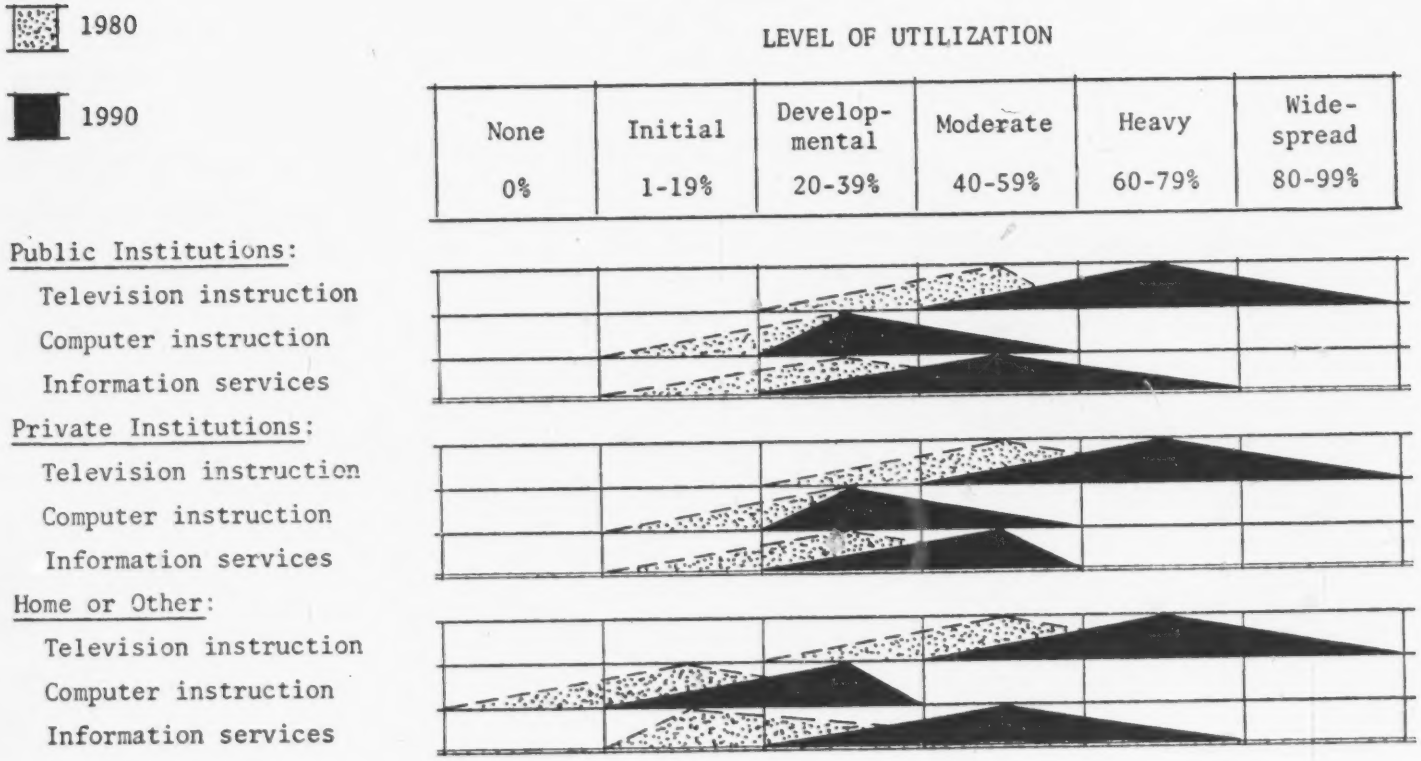
UTILIZATION OF TECHNOLOGY IN VOCATIONAL AND TECHNICAL EDUCATION*



*The triangle represents the middle 50 percent of the responses, the peak being the median response.

FIGURE 12E

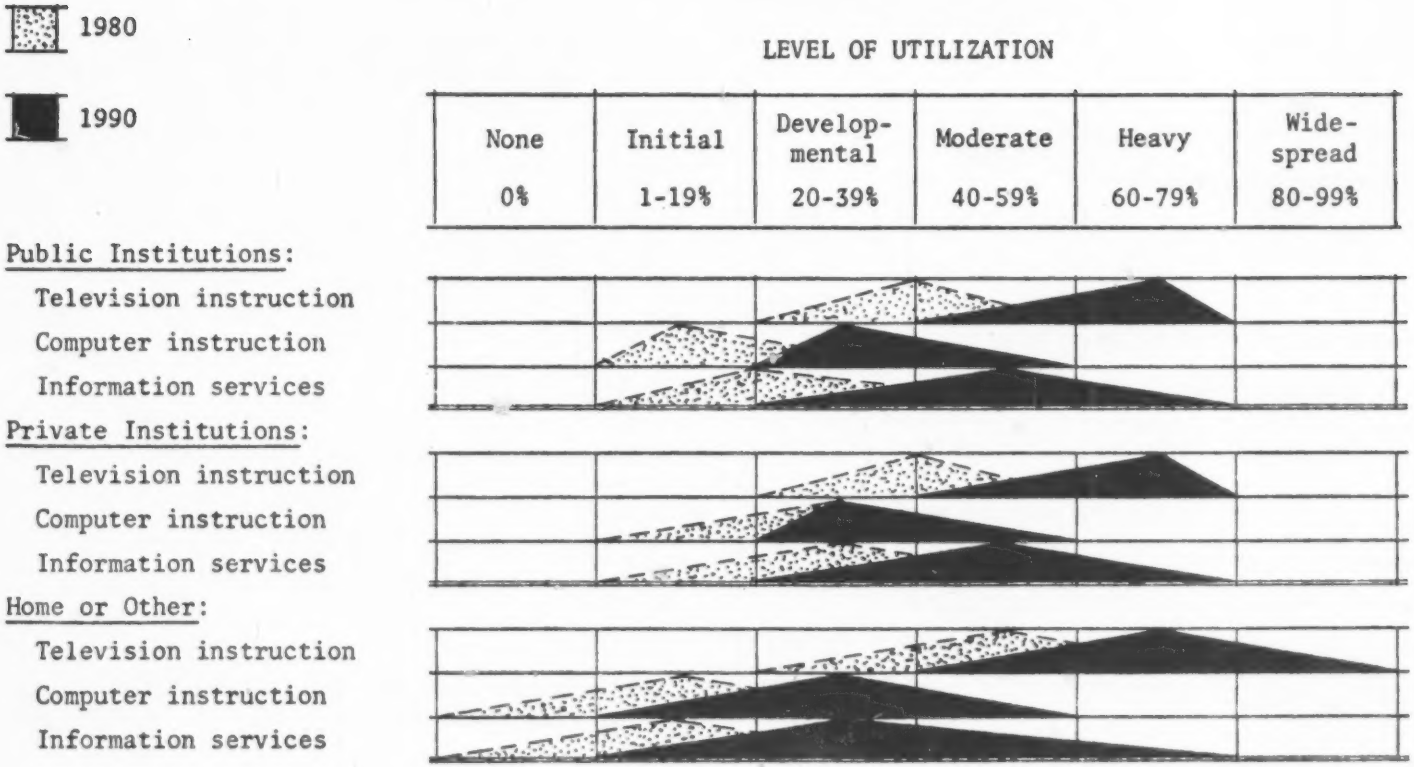
UTILIZATION OF TECHNOLOGY IN ADULT AND CONTINUING EDUCATION*



*The triangle represents the middle 50 percent of the responses, the peak being the median response.

FIGURE 12F

UTILIZATION OF TECHNOLOGY IN SPECIAL EDUCATION*

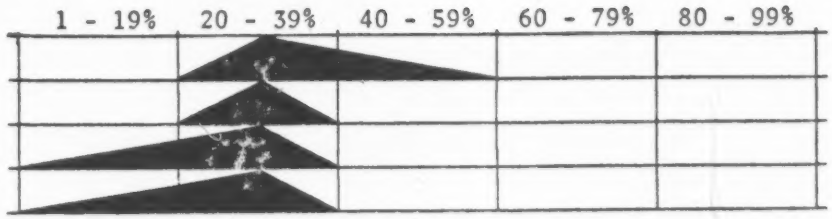


*The triangle represents the middle 50 percent of the responses, the peak being the median response.

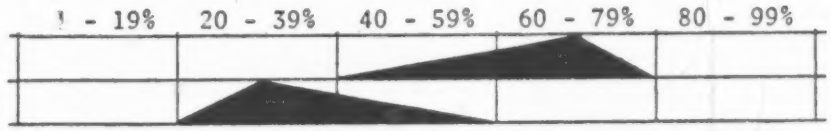
FIGURE 13A

ORGANIZATIONAL STRUCTURES IN LARGE-SCALE DELIVERY SYSTEMS*

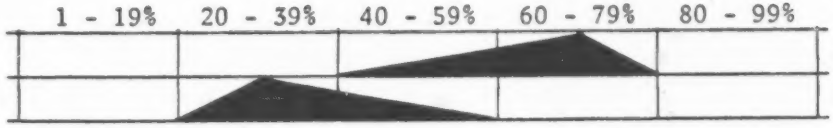
Organization - percent of the co-ordination and operation of the delivery systems is:



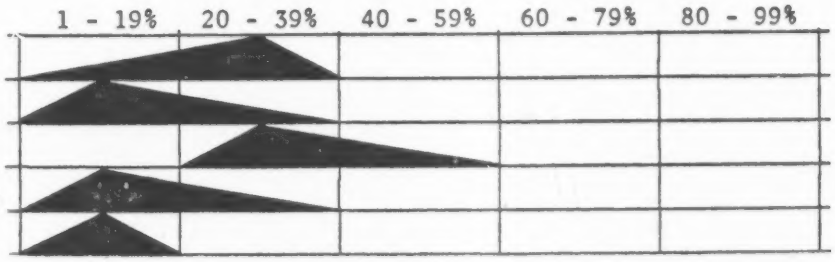
Control - percent of the control of the delivery systems is:



Finances - percent of the funding or financial support of the delivery systems is from sources which are:



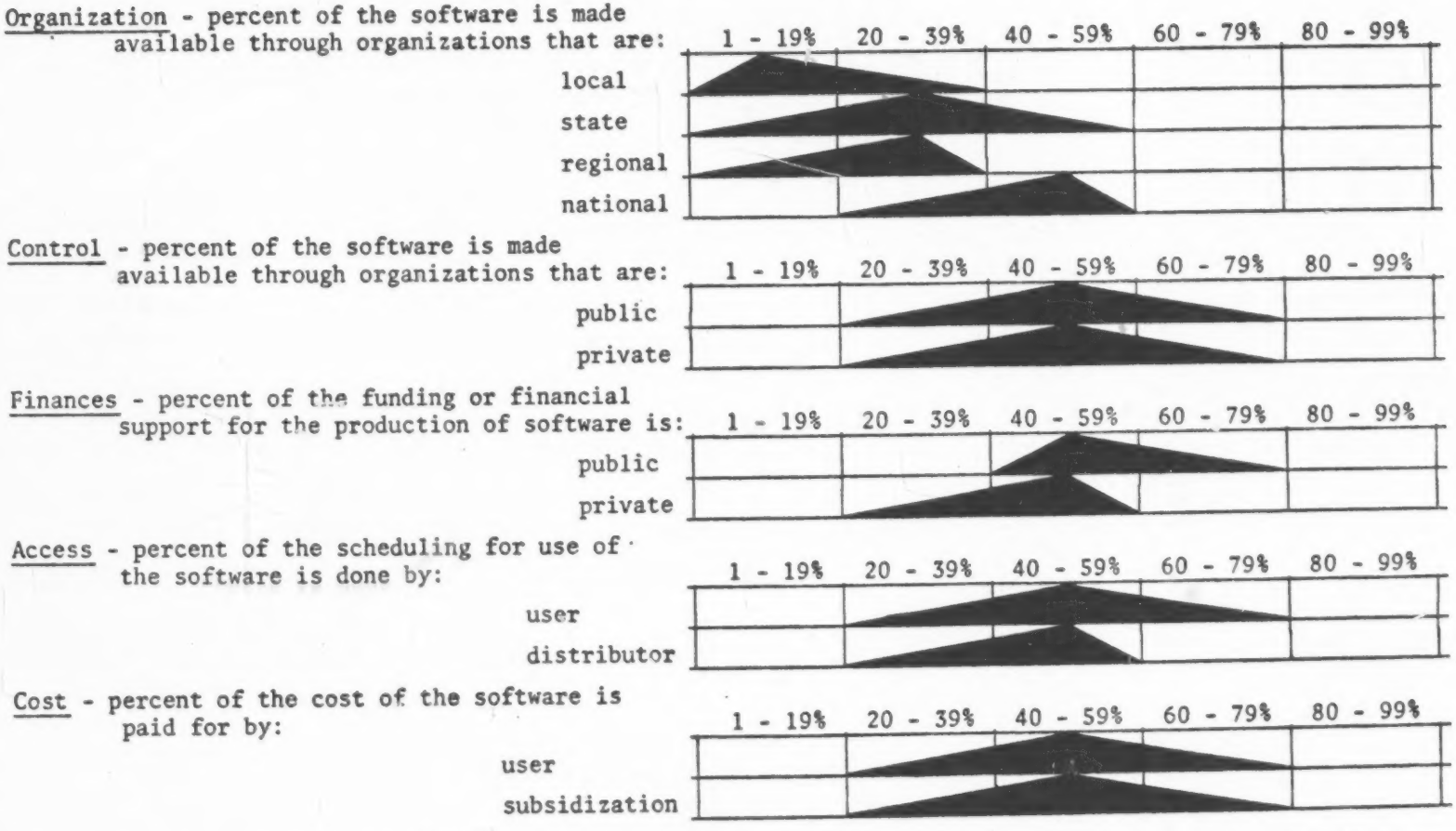
Distribution - percent of the material delivered over the systems is by:



*The triangle represents the middle 50 percent of the responses for the year 1990, the peak being the median response.

FIGURE 13B

ORGANIZATIONAL STRUCTURES IN LARGE-SCALE SOFTWARE SUPPLY SYSTEMS*


Organization - percent of the software is made available through organizations that are:
1 - 19%
20 - 39%
40 - 59%
60 - 79%
80 - 99%
local
state
regional
national
Control - percent of the software is made available through organizations that are:
public
private
Finances - percent of the funding or financial support for the production of software is:
public
private
Access - percent of the scheduling for use of the software is done by:
user
distributor
Cost - percent of the cost of the software is paid for by:
user
subsidization

*The triangle represents the middle 50 percent of the responses for the year 1990, the peak being the median response.

FIGURE 14

VALUES AND OPINIONS OF PEOPLE IN 1990†

1	2	3	4	5	6	7
strong rejection	moderate rejection	slight rejection	neutral	slight acceptance	moderate acceptance	strong acceptance

PUBLIC OPINION POLL (of people in 1990)

		1	2	3	4	5	6	7
1.	The federal government should determine the content of educational software.		(2)					
2.	The development of educational data banks of grades, test scores and personal information on students should contain adequate safeguards to protect the privacy of individuals.							(7)
3.	The individual student should have access to the information about him which is stored in educational data banks.						(6)	
*4.	Educational institutions should be held accountable for the educational methods they use and results they obtain in terms of quantifiably measurable outputs (e.g., using PPBS, PERT, and other productivity measures).						(6)	
5.	If initial costs of implementing educational technology are high, federal or regionally shared money should be used to pay initial costs for poorer schools.						(6)	

*Indicates question was reworded in Round Two.

†Underscoring represents the middle 50 percent of the responses, the circled number is the median response.

FIGURE 14

VALUES AND OPINIONS OF PEOPLE IN 1990 (continued)

1	2	3	4	5	6	7
strong rejection	moderate rejection	slight rejection	neutral	slight acceptance	moderate acceptance	strong acceptance

6.	In an attempt to equalize educational opportunities, educational technology should be used in richer schools to generate savings which could be used to improve poorer schools.	1 2 **3** 4 5 6 7
7.	If educational technology can do the same job for the same cost, it should be used to replace the teacher.	1 2 **3** 4 5 6 7
8.	If educational technology can do the same job for considerably less cost, it should be used to replace the teacher.	1 2 3 4 **5** 6 7
9.	If the combination of educational technology and teacher can do a better job at somewhat higher costs, the combination should be used.	1 2 3 4 5 **6** 7
10.	If the combination of educational technology and teacher can do a better job at the same cost, the combination should be used.	1 2 3 4 5 6 **7**
11.	Para-professionals, student teachers, multi-media technologists, and teacher's aids should be accepted as important and necessary components of the educational process.	1 2 3 4 5 **6** 7
12.	Educational technology should be looked upon by teachers as a threat to their job security or an infringement upon their classroom control.	1 **2** 3 4 5 6 7
*13.	Assuming it is true that technology creates feelings of alienation, deindividualization or dehumanization, then it should be kept out of education, no matter what the learning benefits are.	1 2 3 **4** 5 6 7

FIGURE 14

VALUES AND OPINIONS OF PEOPLE IN 1990 (continued)

1	2	3	4	5	6	7
strong rejection	moderate rejection	slight rejection	neutral	slight acceptance	moderate acceptance	strong acceptance

14.	Curricula should contain significant amounts of non-academic (experiential) items and should remain highly flexible in content.	1 2 3 4 **5** 6 7
*15.	Assuming that educational technology cannot effectively transmit certain socialization and cultural values, methods and institutions similar to those in 1973 should be maintained to accomplish these purposes.	1 2 3 4 **5** 6 7
16.	National or regional degree-granting organizations should be created to relieve the job of certification and degree-granting from educational institutions.	1 2 3 **4** 5 6 7
*17.	Schools should continue their "custodial functions" (i.e., babysitting children during the day and keeping them out of the labor force).	1 2 3 4 **5** 6 7
18.	With the aid of technology, educational institutions should be better able to define their goals and functions.	1 2 3 4 **5** 6 7
*19.	Standardized programming should be avoided because it produces a bland and sterile, mass education.	1 2 3 **4** 5 6 7
20.	Education should be thought of as something which extends throughout a lifetime, with individuals leaving and returning at various times in their lives.	1 2 3 4 5 6 **7**
21.	Copyright laws should protect an author's rights for instructional materials which become part of a computerized software system.	1 2 3 4 5 **6** 7

FIGURE 14

VALUES AND OPINIONS OF PEOPLE IN 1990 (continued)

1	2	3	4	5	6	7
strong rejection	moderate rejection	slight rejection	neutral	slight acceptance	moderate acceptance	strong acceptance

22.	Copyright laws should enable the freest possible access to instructional materials by students and teachers.	1 2 3 4 5 **6** 7
23.	The socio-economic background of a student should determine the kind of educational opportunity provided to a student.	**1** **2** 3 4 5 6 7
24.	Educational programming should incorporate elements of entertainment into its material.	1 2 3 4 5 **6** 7
25.	Education should be available to all who want it 24 hours per day, 365 days per year.	1 2 3 4 5 **6** 7
26.	Standardized programming should be used in poorer school districts while affluent school districts should take advantage of the variety and diversity of programming which they can afford.	1 **2** **3** 4 5 6 7
27.	Technology should be used to study ways to improve theories of behavioral conditioning so that students will learn the correct responses with greater ease and speed.	1 2 **3** 4 **5** 6 7

For the 1990 estimates of utilization and organizational structures shown in these graphs, the middle 50 percent of the Round Two responses are indicated by an area covered with a shaded triangle, the peak of the triangle representing the median response. For the 1980 estimates of utilization levels, the middle 50 percent of the Round One responses are indicated by an area covered with a dotted triangle, the peak of the triangle representing the median response. For the estimates of the values and opinions held by people in 1990, the middle 50 percent of the responses are underscored and the median response is circled.

SUMMARIZED COMMENTS

Summarized comments are extracted from the justifications given by the panelists for the estimates which they observed in the utilization levels and social impacts in both Round One and Round Two. An attempt is made to convey the general sentiment of the majority of the participants; thus, conflicting comments have been blended to arrive at a compromise opinion which might satisfy a majority of the panelists. Each panelist commented upon different points in varying lengths; therefore, these summarized comments represent a composite and generalized set of opinions. They are presented as follows: equal opportunity and individualized instruction, technology versus humanity, societal change, economic issues, political issues, and utilization levels (see Figure 15).

FIGURE 15

SUMMARIZED COMMENTS

Summarized comments extracted from opinions of experts who participated in a Delphi study of the future of technology in education expressing their view of what education in 1990 will be like.

Equal Opportunity and Individualized Instruction:

There is an insistence upon equalization of educational opportunities, regardless of socioeconomic background. One method for doing this is through the use of educational technology by everyone who can benefit from it.

> While rich and poor neighborhoods still exist, these differences do not cause differences in educational opportunities. The disadvantaged and low income people are provided sufficient resources to develop the technology in whichever manner they believe to be most helpful for them.
>
> Supplying the necessary resources is difficult; subsidization of poor school districts by rich ones or increased taxation are unpopular in most places.
>
> As an ideal, equal opportunity sounds fine. But problems occur in defining what it is. For example, where equalized outputs (reading ability, etc.) are desired, unequal inputs (special instructional materials) are required and technology risks criticism for tracking.

The concern for the individual leads to emphasis upon individualized instruction; instructional materials are designed to fit individual needs and desires.

> Consumer movements argue strongly to protect the right of each individual to have some input into the design of his or her educational experience as well as some control over the content and scheduling of educational materials "consumed."
>
> Who defines "individual needs"? This dilemma is unresolved for early childhood, primary, and secondary education; some say parents, some say teachers, some say students.
>
> Individualized instruction conflicts with standardized programming. Required courses or materials, which at one time were thought valuable for all students to learn, also conflict with individualized instruction.

FIGURE 15

SUMMARIZED COMMENTS (continued)

It is important that the individual recognize that he is learning so that he will continue to be interested. Further, complete independence is not possible as there must be some co-ordination with local controllers.

Technology versus Humanity:

Apprehension exists due to previous failures and misapplications of technology as well as the massive "technologization" of many aspects of life. This anti-technical bias reduces the credibility of educational technology; fears develop that its use will be required. Yet, there is still a desire for the benefits which technology can provide and, hence, a willingness to accept many of the drawbacks and disadvantages which come with technology.

Technology is seen as one vehicle in the process of rehumanizing a technological society, serving to create a humanized educational experience. Man and machine are used to complement each other, together teaching more subjects more effectively. In the process the individual is strengthened in some ways, and is weakened in others.

Educational technology has advanced beyond the stage of being an efficient information transfer medium; it can provide motivation for learning, stimulate curiosity, and familiarize people with technology.

Issues of the threat of technology to teachers in areas of job security, classroom control, and dehumanization have diminished in importance as potential conflicts have been resolved. Nevertheless, implementation of technology has been delayed as a result of fears, some groundless and some not, which have been held by people. For example, there is a fear that technology will dominate, that children will believe that things are run by machines and not people.

Some failures of previous technology were inevitable; others were the result of poor planning, poor execution, inadequate assessments, or ineffective tools, or all of these.

Technology is fully subordinate to human choice, up to a point; some technology dictates the choice (e.g., the choice to turn on the picture portion of a videophone is dictated to some extent by the fact that the technology is available and social pressures are present).

FIGURE 15

SUMMARIZED COMMENTS (continued)

While the number of teachers has been reduced, teachers are seldom replaced by technology; they are necessary to provide the social setting in education and to occupy essential roles of love, affection, motivation, counseling, and group activity management. Some subjects which are taught bring out the individuality, skills in human interaction, and understanding of the affective domain which the teacher possesses. Early childhood education is an example of an area where warmth, understanding, and personal attention are necessary, along with constructive discipline.

On the other hand, the roles of the teacher have been expanded. Some subjects are taught by educational technology with the teacher acting as a resource person or learning manager; others require the use of para-professionals, student teachers, multi-media technologists, and teacher's aides as important and necessary components.

The abundance of highly qualified teachers keeps the competition keen. Teachers improve in their ability to do research and production of instructional materials. Conflicts over tenure and seniority are common as many teacher's unions lead the fight against technology.

Appropriate manpower planning has helped to reduce the threat of technology and, in fact, has enriched jobs and life.

The role of education is to support the parents and home environment, not replace them; education, as always, continues to do only those things which parents cannot or will not do themselves.

Education, while striving for understanding, can incorporate elements of entertainment. The entertainment content, however, is different for each category of education and different for each individual student. Learning can be enormously enjoyable and satisfying as well as involve discomforting errors and disappointments. Certain educational materials are judged more for their ability to teach or impart some bit of knowledge than for their entertaining qualities.

The joy of learning is in learning; some of this joy can be communicated through technology, but some of it must occur through human interaction.

While technology can be used to program the correct answers in science and math, it must be used with caution in other areas where "correct answers" are more in doubt. The real contribution of technology is in the educational process, helping people to learn faster and easier.

FIGURE 15

SUMMARIZED COMMENTS (continued)

Societal Change:

Society, like any large, biological system, is complex and stable; moreover, it changes slowly. Technology, an aggressive and fast-moving beast, is of a nature which encourages rapid change. In concert, these two forces can work to introduce gradual changes in social institutions and social values. Combined with other forces of change such as politics and economics, significant new relationships in society can occur.

While the distribution of values among people remains much the same as in previous times, schools have been forced to change many of their goals and functions. A wide variety of educational opportunities are available, most of them involving human-to-human interaction. People share opinions by means of technology; people share opinions in spite of technology.

The number of hours spent working has decreased and the number of hours spent in leisure time has increased. There is increased stratification in society as inner-city residents and outer-city residents see themselves as different; at the same time, there are closer ties between city and rural residents. Information gathering and learning have been extended, beginning at birth and not ending until death. Increased longevity has meant a great increase in adult and continuing education. Furthermore, the demand for cultural activities, entertainment, and informal education is increasing constantly.

The adults, many of whom as children experienced much technological change (e.g., television, computers, satellites, stereos), are more prepared to accept further technological changes. Still, they are not as ready or eager as their children.

While many people voice publicly the ideals and values of a humanized educational experience, they often contradict these ideals with the votes and economic decisions which they make. Bond issues still fail regularly. Thus, the individual himself contributes to the slowness of societal change.

Economic Issues:

The cost of educational technology has been and continues to be a major concern. Heavy federal funding and, along with this, control by public agencies is commonplace. Funds are distributed to states which in turn distribute them as needed. Part of the money goes for initial investments in mechanical devices which are needed; most of it goes for the development of the content, the programming, and the nature of the services provided.

FIGURE 15

SUMMARIZED COMMENTS (continued)

Although some design of instructional materials and services can be expected locally, regional or national organizations predominate because of the economies of scale and improved quality which they can offer.

Private enterprise, notably former publishing corporations, has become involved in designing and producing instructional materials on a competitive basis. Private enterprise also competes for the information services market. Some have found this to be a lucrative endeavor; others have gone bankrupt.

Because of the universal nature of some of the educational services, national subsidization serves as an incentive in those areas in which private enterprise is unable or unwilling to venture.

Some of the development of instructional materials and the design of services is done at universities for contracts from government and industry.

The current approach is to view educational technology as a service which combines the elements of hardware and software into a package which is distributed to the educational institutions or to individuals.

Education has become a more capital-intensive endeavor. Where it used to be labor-intensive, the educational process now combines teachers and technology in cost-effective ways. Measures of accountability and productivity are widely used.

Increased taxes have caused citizens to demand accountable, productive, and efficient operation of the service industries (health, education, and welfare). Previous wastes of time and money resources in these areas have been curbed.

Saving money through more productive mixes of teachers and technology has become a major concern of both public and private schools. In addition, public schools use technology more when funding increases; private schools use technology more when innovative instructional methods are needed to attract students.

Certain aspects of education never have and never will lend themselves to being measured in quantified ways. This is because certain variables involve aesthetic, subjective judgments; furthermore, the many variables in constant, complex interactions with each other make it virtually impossible to find the causal relationships in education.

FIGURE 15

SUMMARIZED COMMENTS (continued)

Political Issues:

Concerns for standardization and interchangeability of various components of the delivery systems, concerns for equalization of educational opportunity, concerns for adequate copyright protection, and concerns for planning and administration at a comprehensive, national level, have caused greater involvement by the national government. Regional consortia have been found effective for organizing and storing large quantities of instructional materials and services, acting like large-scale libraries. Local control of selection and scheduling of programs and services, however, remains the most important feature of the organization of large-scale educational technology.

Copyright laws have changed but continue to be a problem. The dilemma is that protection is desired for the author's rights and rewards are necessary for his creative endeavors, but sufficient unrestricted access to information is also desired for students and teachers. While additional rewards are available for authors, the performers, editors, and technicians are increasingly demanding copyright protection.

Regional consortia play a limited role in software production because they are not political entities, that is, they must derive their financial and political support either from the state or national governments.

The success of educational technology has rested to a large extent upon the ability of the local user to choose the time and content of the material or services he desires to use; however, some degree of co-ordination and planning has been necessary with the various distribution centers.

Local control of the operation and co-ordination of the delivery systems remains, especially for cable television systems.

Education has become a lifetime experience; it is being offered at more times of the day, more days of the year, including special holiday and vacation education-travel programs. National standards of education, national granting of degrees, and universal, free higher education are ideas which are increasing in popularity.

Public schools are generally involved in the traditional educational programs of primary, secondary, and higher education.

Private schools are generally most active in the non-traditional educational programs such as early childhood, vocational, adult, and special education. Non-academic and individual interest items are provided in curricula. Technology has been combined with resources of military and industrial training schools for

FIGURE 15

SUMMARIZED COMMENTS (continued)

increased opportunities in vocational and adult education. While the human component continues to be vital, technology has contributed to greater educational offerings for the large number of elderly and other special education groups.

Implementation of educational technology has been more troublesome than was previously imagined, partly due to confusion over regulations and policies of government. Indecision at the national level has generally slowed the use of educational technology. National agencies conflict with local ones as to who should be formulating policies, goals, and functions. Bureaucracy has reared its ugly head to add to the delays and confusion.

Old organizational structures, slow to change, have been replaced by more open and more flexible ones. Newly established educational institutions and homes are utilizing technology to a greater extent than are the existing institutions. Some of the conservatism of previous times has given way to a more open attitude toward innovation and change.

Utilization Levels:

Cable television has spread and grown fast. Originally thought of as a stunted facility with opportunities only for mass entertainment, cable television has become available and desirable in a great number of homes. Where cable exists, so do television instruction, some information services, and bits of computer instruction.

The "wired city" has come about as cable television and communications satellites have combined to reduce costs, provide greater channel capacity, and increase the availability of informational services. Videocassettes, videodiscs, sound only channels, and still-frame pictures are features of some services.

Educational delivery systems will make use primarily of cable television; use of over-the-air, terrestrial microwave, communications satellites, and other (optical fibers, lasers) media of delivery will be necessary to cover larger distances.

Television instruction, computer instruction, and information services are hard to distinguish from each other. As much as they are separable, television instruction has expanded greatly, with large quantities of diverse, high quality, instructional programming available, particularly in early childhood education. Computer instruction in the home remains too expensive for much widespread use. Information services are found where there is a high demand for access to much information.

FIGURE 15

SUMMARIZED COMMENTS (continued)

The use of television and computers does not mean that the instructional materials presented are of any better quality than previous material, even though the technology appreciably influences the type and method of instruction presented.

Computer instruction, supporting human guidance and management of instruction, has been found useful in teaching language, math, and writing skills to rural, ghetto, and highly gifted students.

Information services are found more useful for reference purposes than for instructional purposes. Computers here act as information switching mechanisms rather than as message transforming mechanisms.

The cost of home terminals has become low enough to allow a great number of educational services in the home; some uses of technology, however, remain too expensive for the average person. This prompts the growth of community centers for socializing and education.

Trends in the utilization of educational technology follow patterns similar to other trends. Growth often occurs exponentially, meaning that utilization is either initial or widespread, with very little moderate levels. Some trends reach limits at lower levels of use; others reach limits at higher levels; still others are cyclical and will continue to fluctuate in the future.

National educational services exist which make use of national computer and information utilities.

Innovation in educational technology in the United States is challenged by advances in these areas by other countries (e.g. Japan).

Much education in the home is sponsored by public and private organizations.

Technology works best where it fits with the needs of the people involved. An example is the new instructional and informational service provided for the handicapped and the blind.

SCENARIO

The year is 1990; the place is the United States. Usage of large-scale, educational telecommunications technology is generally moderate; that is, it can be found in around half of the various educational institutions. Changes in political, social, and economic conditions have influenced the growth of the technology; likewise, growth of the technology has influenced these conditions.

Cable television has been so successful that many cities are wired into large networks providing an assortment of communications services, many of them educational--television instruction, computer instruction, and information services. These same opportunities are also available to rural residents through cable television in connection with communications satellites and terrestrial microwave transmission facilities.

Though difficult to distinguish among these three types of educational services, each can be seen to have a somewhat different function. Television instruction, generally one-way broadcasting of information, is in heavy use (60-79 percent of the locations) in homes and public institutions, and is in moderate (40-59 percent of the locations) to heavy use in private institutions. A large variety of diverse instructional materials of high quality are available, particularly in early childhood education. Computer instruction, generally two-way interactive learning guided by a computer, is in developmental use (20-39 percent of the locations) in all educational institutions, except for higher and vocational and technical education where the use is moderate. Computer instruction, while still too

expensive for much home use, has been helpful in specialized learning situations (e.g., math, language, writing skills) in a variety of locations, including community centers. Information services, such as computerized library systems, educational data banks, time-shared computers, management information systems, and data processing, are in moderate use in the public and private institutions; in homes the use is developmental. Exceptions are early childhood education where the use is developmental in all cases, and higher and adult and continuing education where the use is moderate in all cases. Information services are found more useful as reference aids rather than instructional aids.

The growth of the technology has not been strictly exponential; there have been limits to the growth in certain areas, and the growth has been fluctuating in cycles in other areas. This is due primarily to the political, social, and economic factors which have been in operation.

When large-scale, educational telecommunications technology was first introduced prior to 1980, the costs were prohibitive and funding outlooks were very bleak. Consequently, the use of technology as an addition to educational budgets was dropped in favor of use of an optimum combination of teachers plus technology which didn't strain budgets. This pattern of use has continued today. There is a slight rejection of the idea that technology be used to replace the teacher if it does the same job for the same cost; however, there is a slight acceptance of the idea of technology replacing teachers if it does the same job for less cost. Furthermore, if the combination of technology and teacher can together do a better job at somewhat higher costs,

there is moderate acceptance; finally, if the combination of technology and teacher can together do a better job at the same cost, there is a strong acceptance of this complementary educational program.

As a result of this pattern of use, education is becoming more capital-intensive, aided by the use of cost-effectiveness, accountability, and productivity measures. With the increases in taxes, many citizens demand the use of these quantified techniques of measurement to ascertain the efficiency of health, education, and welfare services. Problems arise, however, when quantified methods of cost accounting are used; the many, subjective variables in constant and complex interaction with other variables make it virtually impossible to establish the causal relationships in education.

Different sectors of the economy and of education have moved at different paces in the development of this technology. Public schools, under increased pressure to educate more people using the same resources, wanted to make the move to a combination of technology and teacher. Research, development, and implementation costs, however, were too high without federal financial assistance. As a result, a few of the richer schools were able to adopt some of the technology, use it successfully, and thus give the rest of the schools ample reason to complain to local, state, and finally national politicians about equality of educational opportunities and the right to individualized instruction. Political discussions entailed many controversies which essentially delayed any decision on massive federal funding programs.

Private schools, under pressure to maintain enrollments and reduce costs, also wanted to move with technology and teacher combinations. They were faced with a similar dilemma in terms of no federal

funding of programs for educational technology. They resorted to using some of the educational programs aired by the Public Broadcasting Service. The private corporations who had sponsored some of these shows then saw a potential market in educational instructional services. Being already familiar with aspects of vocational and technical education and adult and continuing education through their own industrial training programs, they adapted their methods into instructional materials packages complete with the necessary hardware. These were sold to various private institutions of education, who then found that enrollments were increasing in these specialized areas and costs were reasonable. Consequently, many private institutions began to develop into non-traditional educational institutions; adult and continuing, vocational and technical, early childhood, and special education were services for which the user would pay. A large variety of diverse educational services began to appear in this new market. Former publishing corporations became "electronic publishers"; national digital data common carriers became successful; educational service industries grew rapidly offering interconnected networks for high speed information transfer, miniaturization of communications media, computerized library and data processing services, and advanced planning systems; multi-purpose communications satellite companies leased a large number of educational channels.

The public sector, spurred by these successes in the private sector, increased the pressure on politicians to provide similar opportunities in public schools. The previous indecision melted and heavy federal funding was initiated. With demands for free education through college for everyone, public schools focused their efforts on primary,

secondary and higher education. The production of instructional materials and information services was chaotic. Some local production was being done; some states were contracting with private corporations to provide educational systems for all of their schools; some regional consortia and regional educational laboratories were used to research and develop larger-scale services. The national government, however, to enable more efficient planning and administration of these services; to ensure standardization and interchangeability of various components of the systems; and to provide an equalized, individualized educational opportunity for each and every person; established the present Public Education Service. Its functions are to control and regulate the use of technology in public schools, to contract for large-scale production of instructional materials, and to provide distribution facilities for the variety of information services being offered. Recognized very early was the necessity of a large degree of local control over the scheduling and selection of materials and services. The success of the present system is due in large part to this decentralization in operation. There is a moderate rejection of federal government control over the content of educational software.

Several political changes have occurred as a result of this technology. One is the passage of several laws to insure that poorer school districts would be aided by federally or regionally shared money in implementing the technology. Originally, it was proposed to use technology in richer school districts to generate savings for poorer school districts, but this was rejected. Another change has been the safeguarding of individual rights to privacy of information stored

in large, educational data banks, including the right of students to have access to the information about them which is stored in these data banks. The political issue which still causes the most problems is the copyright question. How do you provide protection of an author's rights and rewards for his creative endeavors when his material becomes part of large-scale, educational technology systems? How do you insure freest possible access to instructional materials by students and teachers, and not violate copyrights? Furthermore, what about the demands for copyright protection for performers, editors, and technicians? Several interim changes in copyright have occurred, but the basic dilemma remains.

The social changes, the consequences of educational technology as well as the consequences of value changes in society, have been significant. In general, technological change has been paced to proceed harmoniously with social change so that disruptions which occurred earlier do not reoccur. When technology was first introduced, teachers and their unions organized strikes and boycotts of schools using technology; they feared that technology would replace them and turn education into a dehumanizing, automated, assembly-line production process. Support for these ideas came from the growing number of "anti-technology" crusaders who saw the increasing "technologization" of many aspects of life leading to decreases in the quality of life and loss of the dignity of man. These specific reactions to technology were aided by the more general cultural value changes and new awarenesses which were occurring at the time. Misapplications and failure of technology further encouraged demands for

complete assessments of the full range of impacts which technology might have.

By now teachers have gotten over a lot of their earlier fears. Trained in the use of technology, they have expanded their roles to include being a resource person or learning manager; they are aided by para-professionals, student teachers, teacher's aids, and multi-media specialists and technicians--all of whom are vital parts of the complex educational process. The job of the teacher has become more enjoyable as elements of entertainment can be found in many educational programs.

As a result of the new values, and partly because of technology, educational institutions have been able to better define their goals and functions. Education is now thought of as a lifetime experience, with people leaving and returning at various times in their lives. Education is offered at more times of the day, more days of the year, including special holiday and vacation education-travel programs. Curricula contain large amounts of non-academic and experiential items, and they remain highly flexible in content. Standardized programming is available for those who want it, but not required anywhere. Schools still serve a "custodial function": they babysit children during the day and keep them occupied while they are not in the labor force. National certification and national granting of degrees is being done in some technical areas, but schools and states have retained their right to these functions in most areas. The socialization function of education is still carried on in traditional schools using traditional methods; however, new organizational structures which are more open and more flexible are developing. Homes

and business offices are becoming educational and cultural centers as well. Many locations of human activity are becoming multi-purpose--recreation, education, and career are being blended together to produce happy, productive people.

Chapter 7

CRITIQUE AND CONCLUSIONS

(So What?)

Having now completed a forecast of educational telecommunications technology, the prudent prognosticator becomes vulnerable to the same critical examination which was given to other forecasts and methodologies. What follows is an initial critique of definitions, design, and results of the Delphi forecast done for this thesis. This is then followed by a concluding section of suggested improvements for future forecasts.

DEFINITIONS

Educational technology was broken down into television instruction, computer instruction, and information services. As pointed out by many of the panelists, these distinctions are somewhat arbitrary because the technology may evolve so as to blend elements of each type of technology into wholly integrated packages of services available to educational institutions. As the technology develops, the packages will become more complex, offering more services. Thus, the distinction among these types of technology may prove as unclear for interpreters of this forecast as it was for the panelists. Furthermore, the definitions can be criticized for including too much under one heading. For example, information services combines all kinds of

computer services with all kinds of library services with all kinds of audio-visual services. It is possible that the utilization of each of these services will not be close enough to have combined them into one grouping.

Definitions of educational categories also might have combined too much under one heading. Special education opportunities may be available sooner for elderly people than for mental patients or prisoners. Adult and continuing education opportunities may be available in continuing professional education sooner than they are available in nonprofessional, recreational education. Furthermore, a reorganization of the categories of education along the lines of age and place of education might be more meaningful.

Definitions of utilization levels are perhaps the most disturbing, as noticed from the comments of the participants. The level of utilization is limited to a measure of only the percentage of institutions in which technology is available to be used. This could mean the use for only one hour per year of television instruction in the home to qualify in that category. Whether such figures truly indicate utilization levels is questionable. A better indicator may have been the percentage of instructional hours in which the technology was used. A complete picture of utilization would include both the percentage of instructional hours using technology and the percentage of institutions in which the technology is available for use. Also, it was very difficult to determine what usage is educational. For instance, is it educational usage to watch televised hearings of a Senate investigating committee? Finally, terming the beginning stages of utilization "initial" and "developmental" hints

at the bias that utilization of technology will continue to increase when, in fact, it might never go beyond the initial stages of use.

Definitions of social impacts are misleading when not broken down into the particular educational categories. Questions of who determines individual needs are much different at early childhood, primary, and secondary levels than they are for more advanced types of education. Organizational structures might be different for public institutions than they are for private institutions. The entertainment component in education might vary among the educational programs, according to both age and level of education of each individual.

DESIGN

While the selection of experts may have provided a diverse and varied panel, a comparison of the results by area of interest--education, communications technology, other--was not possible because the selection process was voluntary; that is, prospective panelists each made the decision of whether or not to participate. Thus, it was not possible to form separate and distinct areas of interest from the group of panelists who responded, even though this was originally intended. Also, because the selection process was voluntary, there was no way to insure that a complete range of opinions was obtained. It is possible that only the persons who were optimistic about the future of technology in education have responded. There is evidence for this in the fact that only two of the twenty-four, randomly chosen educators responded to both rounds of the study, and this is a group that might be opposed in some ways to technology in education.

The design of the format may have been too long and too gimmicky. Participation in two hours or more of time machine observations may have seemed frivolous to many busy experts with more urgent matters demanding their attention. It may have appeared that the technology was being sold rather than forecast. Furthermore, even though anonymity of the responses and comments was assured, there may have been suspicions about this in many of the participant's minds; they may not have wanted to have their names connected with a proposal for introducing technology in education. These are certainly understandable fears.

In summary, because the study was of some interest to those who were familiar with the technology and seemed uninteresting or strange to those unfamiliar with the technology, the forecast might reflect inaccuracies.

RESULTS

For those who would use some of the results as an aid to decisionmaking and planning, a couple of crucial caveats should be considered. One is, "Beware, the results might be very optimistic!"; the other is, "Beware, the results might be very pessimistic!" Since it is impossible to foresee the "right" answer, both of these caveats are presented.

The results may be overly optimistic. One indication of this is that people who were opposed to technology in education may not have even responded in the first place. If these possible participants represent a sizeable portion of the population, it is likely that their views may delay the introduction of educational technology.

Another indication is from those who responded; panelists with an expertise in one particular type of technology or type of education noticed that their responses in that particular area were less optimistic than the majority of the other panelists. This occurred so often that one wonders if the more someone knows about a particular technology or area of education, the more pessimistic one becomes about its future. Also, it is difficult to determine the degree of optimism which might be involved in this forecast because no preliminary forecast was done to see what levels of utilization of the technology were thought by the participants to be in existence today, in 1973. It is possible that had participants started from a common assumption about what utilization levels of technology currently are, their forecast of future utilization levels would be different.

On the other hand, the results may be overly pessimistic. In an era of no increases in federal funding of educational programs, an era of suspicion toward any technology, an era of suspicion toward the benefits of education, and an era of instability of many educational institutions, it is possible that boldness and imagination may be lacking in the forecast of technology in education. Its revolutionary potential may indeed bring a "fourth revolution" to education, as predicted by the Carnegie Commission. In addition, it might solve both the financial and equal opportunity problems which are current dilemmas in education. Some of the panelists were of the opinion that the technology would have significant influence in changing a large number of social institutions and values. The value and opinion statements in the study were criticized by several participants for reflecting 1973 values, biases, and conditions. These panelists

predicted a whole new scope of value concerns for 1990. New technological breakthroughs, unforeseen by any of the panelists, are also a possibility.

Having warned the user that the results may be too optimistic or, on the other hand, too pessimistic, it should also be stated that the results are similar to those obtained in two other forecasts. The utilization levels of educational technology which are forecast are very close to those presented in Doyle and Goodwill's Bell Canada study. Very roughly, both forecasts expect a moderate (50 percent) utilization of educational technology in 1990. More detailed comparisons are not possible because the definitions of technology, education, and utilization levels are somewhat different, in each forecast.

The scenario described here is similar in many respects to the scenario written by Edwin Parker about communications technology in education in 1985.[191] Both scenarios see the following: television as the most significant technology; teachers as important components of education; hardware and delivery systems being available but not used for educational purposes until adequate software is available; and utilization of educational technology beginning with early childhood, vocational and technical, adult and continuing, and special education rather than with primary, secondary, and higher education. These other forecasts, then, give some support for the idea that the conclusions may accurately forecast a few aspects of the future of technology in education.

There are other reasons why these results may give an accurate picture of the future, reasons which are related to the theory of

perception. First, there is the role of the self-fulfilling prophecy: the very process of making a forecast may cause that forecast to come true.[192] Once it is made, it changes the situation and becomes part of the forces working for or against the fulfillment of the forecast. Many of the panelists who participated in this forecast may be in the position in the future of making decisions as to the implementation of educational technology. The fact that they have participated in a forecast of this technology, and the results of that forecast, cannot be eliminated from their process of cognitive decisionmaking.
Second is the rationalization of cognitive dissonance, the justification of something which has occurred by the persons involved in making it occur.[193] This principle of psychology suggests, for example, that once technology has been implemented in educational institutions, reasons will be found to justify its implementation and further usage. Related to both of these points about perception is the desire for cognitive consistency in perception.[194] This is basically a phenomenological point which claims that "we live on what we perceive, regardless of the truth or falsehood of those perceptions." People have needs which they perceive as "true" or "real"; they see these needs satisfied by solutions which they perceive as "true" or "real"; perceived solutions to perceived needs lead to satisfaction of the desire for cognitive consistency. Thus, for example, if educational technology is perceived as a solution to the perceived needs of education, then people will be satisfied, cognitively at least. Emotional satisfaction, though, is not as clearly understood as these cognitive principles.

SUGGESTED IMPROVEMENTS

Just as improvements were suggested for previous forecasts, several recommendations for further refinements can be made for this forecast. One would be to expand the definitions and the panel of experts; a wider range of both would enhance the completeness of the study. Definitions of technology could be expanded to include the inter-relatedness of the various types of technology as well as differentiate further among the information services; definitions of educational categories could be expanded to reflect the differences between smaller subgroups of each category; definitions of utilization could be expanded to include both the percent of locations as well as the percent of use at those locations; definitions of social impacts could be expanded to include differences for each type of education and each type of institution. The panel of experts could be expanded to include a full range of expertise in sufficient numbers to be divided into sub-panels which could then interact with each other through separate forecasts. A panel of sufficient size would enable further breakdowns according to particular categories of education or types of technology. For example, one could see what a private school administrator would forecast for utilization of computer instruction, or what computer technologists would forecast for the attitudes of teachers in public schools.

A forecast using a panel composed of teachers and administrators could provide valuable information for those interested in the future of educational technology in schools. Forecasts of vocational and technical education and special education could be reworded to approximate more closely common usage definitions.

Another suggestion would be to continue to expand this forecast into an assessment. This would mean an analysis of the impacts and relative merit of various possibilities for educational technology. The alternatives could be expanded fully to include all likely trade-offs and consequences; then these alternatives could be ranked in order of desirability. This then moves out of the area of technological forecasting and into the area of technological planning.[195] And planners are just as suspect as forecasters, as Unamuno has observed:

> A young man who, feeling he was ripe enough to choose a wife, set about to find his mate in a truly scientific fashion. He wrote down a thorough analysis of his own self, mind, body and soul; then a similar analysis of the perfect Spanish citizen it was his duty to procreate; and finally, by composing these two premises, an analysis of the wife he was in duty bound to choose. This done, he cries out: But that is exactly Miss So-and-So. Blonde, brachycephalous, tall, well covered with shapely flesh, blue-eyed, a milk-white complexion...--the very thing. He folded his paper, put it in his pocket and at once left for the paragon's house to put his obvious plan to her.
>
> He ran downstairs from his flat and stood at the street door. Raining. Shall I run upstairs again for an umbrella? While he hesitated, he heard the neat, repeated knock of light footsteps on the wet pavement. He looked around. A young woman was approaching; struggling against the wind and rain so that all the umbrella allowed him to see of her was two, thin, elegant legs and two impertinent little feet. How delightful, he thought. He followed her, on and on, getting angrier and angrier with himself. Why. She is dolichocephalous. Her hair is dark, downright black. I bet her eyes are black. She's as thin as they make them. The very opposite of what I wrote down in my paper. It is really absurd. On he went. Absurd. She turned a corner. Absurd. He followed. He went upstairs. Absurd. He proposed. Absurd. He married her.[196]

John Steinbeck has expressed this same sentiment by observing that the best laid plans of mice and men often go astray.[197]

A final recommendation is to include a bit of madness, the creative madness which Plato spoke of as necessary in poets:

> He who without Muses' madness in his soul comes knocking at the door of poesy and thinks that art will make him anything fit to be called a poet, finds that the poetry he indites in his sober senses is beaten hollow by the poetry of madmen.[198]

It is this madness which may give the forecaster the necessary courage and boldness of imagination to risk predicting intuitive insights which otherwise would remain suppressed. And as Shakespeare has poignantly proffered:

> "Though this be madness, yet there is method in't."[199]

FOOTNOTES

[1]Charles L. Dodgson [Lewis Carroll], Through the Looking Glass, in Martin Gardner, The Annotated Alice (New York: Clarkson N. Potter, 1960), pp. 247-8.

[2]Fred J. Polak, Prognostics: A Science in the Making Surveys the Future (New York: Elsevier Publishing Co., 1971), p. 221.

[3]Marvin J. Cetron and Christine A. Ralph, Industrial Applications of Technological Forecasting: It's Utilization in R & D Management (New York: John Wiley & Sons, 1971), p. 9.

[4]Samuel Clemens [Mark Twain], Life on the Mississippi (New York: Harper and Brothers, 1917), p. 156; also used by Barry Commoner, The Closing Circle (New York: Alfred A. Knopf, 1971), p. 216.

[5]Elise Boulding, "Futuristics and the Imagining Capacity of the West," in Human Futuristics, eds. Magoroh Maruyama and James Dator (University of Hawaii: Social Science Research Institute, 1971), p. 34.

[6]National Academy of Engineering, Committee on Public Engineering Policy, A Study of Technology Assessment, prepared for the Committee on Science and Astronautics, U.S. House of Representatives, Washington, D.C., July 1969, pp. 37-75, pp. 107-142.

[7]W. C. Sedlacek et al., Summary Report: Information Transfer Systems Requirement Study, Lockheed Missile and Space Company, NASA-CR-73421, Sunnyvale, California, March 1970.

[8]Carnegie Commission on Higher Education, The Fourth Revolution: Instructional Technology in Higher Education (New York: McGraw-Hill Book Co., June 1972).

[9]Frank J. Doyle and Daniel Z. Goodwill, An Exploration of the Future in Educational Technology, Bell Canada, 1971 .

[10]Ernest J. Anastasio and Judith S. Morgan, Study of Factors That Have Inhibited A More Widespread Use of Computers In The Instructional Process, prepared for National Science Foundation Grant No. NSF GJ 27427, EDUCOM Interuniversity Communications Council, 1972.

[11]R. P. Morgan, J. P. Singh, B. D. Anderson, and E. Greenberg, Satellites for U.S. Education: Needs, Opportunities and Systems, paper presented at AIAA 4th Communications Satellite Systems Conference, Washington, D.C., April 24-26, 1972.

[12]Bertrand de Jouvenel, The Art of Conjecture (New York: Basic Books, 1967).

[13]Cetron and Ralph, op. cit., p. 225.

[14]Boulding, op. cit., pp. 34-48.

[15]Erich Jantsch, Technological Forecasting in Perspective (New York: John Wiley & Sons, 1972), p. 30.

[16]Cetron and Ralph, op. cit., pp. 12-23.

[17]Ibid., p. 475.

[18]Roy C. Amara and Gerald R. Salancik, "Forecasting: From Conjectural Art Toward Science," Futurist, VI (June 1972), p. 115.

[19]Dennis Gabor, Inventing the Future (New York: Alfred A. Knopf, 1964).

[20]William J. J. Gordon, Synectics (New York: Macmillan Books, 1970).

[21]Edward de Bono, The Five-Day Course in Thinking (New York: Signet, 1967).

[22]Boulding, op. cit., pp. 43-47.

[23]Ibid., pp. 41-42.

[24]Ibid.

[25]Robert Boguslaw, The New Utopians: A Study of System Design and Social Change (Englewood Cliffs, N.J.: Prentice Hall, 1965), p. 46ff; Boulding, op. cit., p. 34.

[26]Boulding, op. cit., p. 34.

[27]Ibid., p. 43.

[28]Paul R. Ehrlich and Anne H. Ehrlich, Population, Resources, Environment (San Francisco: W. H. Freeman and Co., 2nd edition, 1972).

[29]Commoner, The Closing Circle.

[30]Joseph P. Martino, Technological Forecasting for Decisionmaking (New York: American Elsevier Publishing Co., 1972), p. 10.

[31]Ralph Lenz, as quoted by Martino, ibid.

[32]Cetron and Ralph, op. cit., p. 10.

[33]Amara and Salancik, op. cit., p. 112

[34]Jantsch, op. cit., p. 15, pp. 30-31.

[35]Ibid., p. 31.

[36]Cetron and Ralph, op. cit., p. xiii.

[37]Jantsch, op. cit., p. 211.

[38]Polak, op. cit., pp. 254-60.

[39]Ibid., p. 391.

[40]Ibid., p. 392.

[41]Ibid., p. 395.

[42]Ibid., p. 396.

[43]Ibid., p. 397.

[44]Ibid., p. 398.

[45]Charles L. Dodgson [Lewis Carroll], Alice's Adventures in Wonderland, in Martin Gardner, The Annotated Alice (New York: Clarkson N. Potter, 1960), pp. 87-8.

[46]Donella H. Meadows et al., The Limits to Growth (New York: Universe Books, 1972), p. 88; Jantsch, op. cit., pp. 143-9; Polak, op. cit., pp. 388-9.

[47]James R. Bright, Fundamentals of Technological Forecasting, the Industrial Management Center, Austin, Texas, [n.d.].

[48]Robert U. Ayres, Technological Forecasting and Long-Range Planning (New York: McGraw-Hill Book Co., 1969), p. 94ff.

[49]Jantsch, op. cit., p. 161.

[50]John McHale, The Future of the Future (New York: George Braziller, 1969), p. 59.

[51]Cetron and Ralph, op. cit., pp. 302-3.

[52]Commoner, op. cit., p. 157, p. 243.

[53]Martino, op. cit., pp. 150-56.

[54]Ibid., p. 156.

[55]Ibid., pp. 160-63.

[56]Polak, op. cit., p. 391.

[57]Meadows et al., op. cit., pp. 124-40.

[58]Polak, op. cit., pp. 184-85.

[59]Kenneth C. Land, Social Indicator Models: An Overview, paper presented at AAAS meeting, December 26-31, 1972.

[60]Anatol Holt, "Digital Systems Viewed as Communications Media," excerpts from AFIPS Workshop, Catalina Island, California, October 14-17, 1971, p. 174.

[61]Commoner, op. cit., p. 243.

[62]Commoner, ibid., p. 200, pp. 207-8; Ehrlich and Ehrlich, op. cit., pp. 176-77, p. 240, p. 385, pp. 390-92.

[63]J. W. Forrester, World Dynamics (Cambridge, Mass.: Wright-Allen Press, 1971); Meadows et al., op. cit.

[64]Ibid., p. 31.

[65]Ibid., pp. 31-35.

[66]Ibid., p. 91.

[67]Forrester, op. cit., Chapter 1.

[68]Meadows et al., op. cit., pp. 140-41.

[69]Ibid.

[70]Ibid.

[71]Ibid., p. 46.

[72]Ibid., p. 179.

[73]Ibid., p. 142.

[74]Ibid., pp. 115-17.

[75]Ayres, op. cit., pp. 143-58.

[76]Herman Kahn and Anthony J. Wiener, The Year 2000: A Framework for Speculation (New York: Macmillan Books, 1967).

[77]Doyle and Goodwill, op. cit.

[78]Olaf Helmer, Social Technology (New York: Basic Books, 1966).

[79]Ayres, op. cit., pp. 149-58.

[80]Polak, op. cit., p. 400; Jantsch, op. cit., p. 140.

[81]Polak, op. cit., p. 401.

[82]Herman Kahn and Anthony J. Wiener, "Faustian Powers and Human Choices," in Futures Conditional, ed. Robert Theobald (New York: Bobbs Merrill Co., 1972), p. 57.

[83]Polak, op. cit., p. 402.

[84]Olaf Helmer, op. cit., pp. 11-39.

[85]Ibid.

[86]Martino, op. cit., pp. 52-54.

[87]Helmer, op. cit., pp. 11-39.

[88]Murray Turoff, "Delphi and Its Potential Impact on Information Systems," Fall 1971 Joint Computer Conference, 1971, p. 317.

[89]Michael T. Bedford, The Future of Communication Services in the Home, Business Planning Group, Bell Canada, 1972, p. 7.

[90]Bright, op. cit., p. 6.

[91]Helmer, op. cit., pp. 90-95.

[92]Ibid.

[93]Turoff, op. cit., p. 318.

[94]Martino, op. cit., pp. 26-29.

[95]Ibid.

[96]Ibid.

[97]Norman C. Dalkey, The Delphi Method: An Experimental Study of Group Opinion, RAND P-5888, June 1969.

[98]Bedford, op. cit., p. 11.

[99]Turoff, op. cit., p. 319.

[100]Joseph P. Martino, "Consistency of Delphi Forecasts," Futurist, IV (April 1970), p. 64.

[101]Turoff, op. cit., p. 317.

[102]Juri Pill, as quoted in Bedford, op. cit., p. 10.

[103]Bedford, ibid., pp. 9-10.

[104]Amara and Salancik, op. cit., pp. 112-16.

[105]Ibid.

[106]Ayres, op. cit., pp. 21-22.

[107]Ibid., p. 19.

[108]Cetron and Ralph, op. cit., p. 42.

[109]Ibid.

[110]National Academy of Engineering, op. cit.

[111]Martin V. Jones, A Technology Assessment Methodology Some Basic Propositions, report prepared by the Mitre Corporation for the Office of Science and Technology, Executive Office of the President, Springfield, Virginia, National Technical Information Service, June 1971, pp. 121-30.

[112]National Acaden of Engineering, op. cit., p. 26.

[113]Ibid., p. 39-40.

[114]Ibid.

[115]Ibid.

[116]Ibid., p. 41.

[117]Ibid., p. 28.

[118]Ibid., pp. 42-44.

[119]Ibid., p. 29.

[120]Ibid., pp. 29-30.

[121]Ibid., p. 70.

[122]Ibid., p. 32.

[123]Ibid., p. 12.

[124]Ibid., p. 13.

[125]Ibid., pp. 12-13.

[126]Ibid., pp. 15-16.

[127]Ibid., p. 17.

[128]Ibid., p. 5.

[129]Ibid., p. 18.

[130]Ibid., p. 12.

[131]Ibid., p. 17.

[132]Sedlacek et al., op. cit., pp. 1-23.

[133]Ibid., p. 2.

[134]Ibid.

[135]Ibid., pp. 5-6.

[136]Ibid., pp. 22-23.

[137]Ibid., pp. 8-9.

[138]Ibid., pp. 8-9, pp. 20-22.

[139]Ibid., pp. 22-23.

[140]Ibid., p. 23.

[141]Carnegie Commission on Higher Education, op. cit., p. 2.

[142]Ibid., pp. 15-28.

[143]Ibid., pp. 29-36.

[144]Ibid., pp. 22-23.

[145]Ibid., p. 40.

[146]Ibid., pp. 39-43.

[147]Ibid., p. 1.

[148]Ibid., pp. 1-2.

[149]Ibid., p. 45.

[150]Ibid., pp. 2-3.

[151]Ibid., p. 3.

[152]Ibid., pp. 3-4.

[153]Ibid., pp. 4-5.

[154]Ibid., pp. 6-7.

[155]Ibid., p. 94.

[156]Doyle and Goodwill, op. cit., p. 1.

[157]Ibid., p. 2.

[158]Ibid.

[159]Ibid., p. 3.

[160]Ibid., pp. 3-6.

[161]Ibid., p. 6.

[162]Ibid., p. 9.

[163]Ibid., pp. 11-15.

[164]Ibid.

[165]Ibid., pp. 16-17.

[166]Ibid.

[167]Ibid., pp. 17-22.

[168]Ibid., pp. 32-34.

[169]Ibid.

[170]Ibid.

[171]Ibid., pp. 23-31.

[172]Ibid.

[173]Ibid., p. 39.

[174]Ibid.

[175]Ibid., p. 49.

[176]Ibid., pp. 49-52.

[177]Ibid., pp. 47-48.

[178]Ibid., pp. 56-59.

[179]Ibid., pp. 60-66.

[180]Anastasio and Morgan, op. cit.

[181]Ibid.

[182]Ibid.

[183]Morgan et al., op. cit., p. 12.

[184]Ibid., p. 13.

[185]Ibid.

[186]Ibid.

[187]Ibid.

[188]Ibid., pp. 12-13.

[189]Cetron and Ralph, op. cit., p. 43.

[190]Martino, Technological Forecasting for Decisionmaking, p. 54.

[191]Edwin B. Parker, "1985," unpublished paper, Communications Department, Stanford University, [n.d.].

[192]Floyd L. Ruch and Philip G. Zimbardo, Psychology and Life (8th ed; Glenview, Illinois: Scott, Foresman and Co., 1971), p. 305.

[193]Ibid., pp. 412-413.

[194]Ibid., p. 304.

[195]Erich Jantsch, Technological Planning and Social Futures (New York: John Wiley & Sons, 1972).

[196]Salvador de Madariaga, "Introduction--Planning for Freedom," in Perspectives of Planning, ed. Erich Jantsch (Paris: Organisation for Economic Co-operation and Development, 1969), p. 37.

[197]John Steinbeck, Of Mice and Men (New York: Signet, 1972); also used by the Scottish poet Robert Burns, "To a Mouse," in a section where he writes "best laid schemes o' mice and men, Gang aft a-gley," 18th century.

[198]A. E. Housman, "The Name and Nature of Poetry," in The Creative Process, ed. Brewster Ghiselin (New York: Mentor, 1952), p. 86.

[199]Hamlet II.ii.

APPENDIXES

Appendix A

PANEL OF EXPERTS

Those participants in a Delphi study on
the future of technology in education
who gave permission to use their names

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Note: Addresses were correct as of May 1973.

BIBLIOGRAPHY

BIBLIOGRAPHY

Amara, Roy C., and Gerald R. Salancik, "Forecasting: From Conjectural Art Toward Science," Futurist, VI (June 1972), 112-116.

Anastasio, Ernest J., and Judith S. Morgan, Study of Factors That Have Inhibited a More Widespread Use of Computers in the Instructional Process, prepared for National Science Foundation Grant No. NSF FJ 27427, EDUCOM Interuniversity Communications Council, 1972.

Ayres, Robert U. Technological Forecasting and Long-Range Planning. New York: McGraw-Hill Book Co., 1969.

Bedford, Michael T. The Future of Communication Services in the Home. Business Planning Group, Bell Canada, 1972.

Boguslaw, Robert. The New Utopians: A Study of System Design and Social Change. Englewood Cliffs, N.J.: Prentice Hall, 1965.

Bright, James R. Fundamentals of Technological Forecasting. The Industrial Management Center, Austin, Texas, [n.d.].

Carnegie Commission on Higher Education. The Fourth Revolution: Instructional Technology in Higher Education. New York: McGraw-Hill Book Co., June 1972.

Cetron, Marvin J., and Christine A. Ralph. Industrial Applications of Technological Forecasting: Its Utilization in R & D Management. New York: John Wiley & Sons, 1971.

Clemens, Samuel [Mark Twain]. Life on the Mississippi. New York: Harper and Brothers, 1917.

Commoner, Barry. The Closing Circle. New York: Alfred A. Knopf, 1971.

Dalkey, Norman C. The Delphi Method: An Experimental Study of Group Opinion. RAND P-5888, June 1969.

De Bono, Edward. Five-Day Course in Thinking. New York: Signet, 1967.

De Jouvenel, Bertrand. The Art of Conjecture. New York: Basic Books, 1967.

Dodgson, Charles L. [Lewis Carroll], Alice's Adventures in Wonderland and Through the Looking Glass, in Martin Gardner, The Annotated Alice. New York: Clarkson N. Potter, 1960.

Doyle, Frank R. and Daniel Z. Goodwill. An Exploration of the Future in Education Technology. Bell Canada, 1971.

Ehrlich, Paul R. and Anne H. Ehrlich. Population, Resources, Environment: Issues in Human Ecology. San Francisco: W. H. Freeman and Co. (2nd ed.), 1972.

Forrester, J. W. World Dynamics. Cambridge, Mass.: Wright-Allen Press, 1971.

Gabor, Dennis. Inventing the Future. New York: Alfred A. Knopf, 1964.

Ghiselin, Brewster, ed. The Creative Process. New York: Mentor, 1952.

Gordon, William J. J. Synectics. New York: Macmillan Books, 1970.

Helmer, Olaf. Social Technology. New York: Basic Books, 1966.

Holt, Anatol, "Digital Systems Viewed as Communications Media," excerpts for AFIPS Workshop, Catalina Island, October 14-17, 1971, Montvale, N.J.: AFIPS Press.

Jantsch, Erich, ed. Perspectives in Planning. Paris: Organization for Economic Co-operation and Development, 1969.

Jantsch, Erich. Technological Forecasting in Perspective. Paris: Organization for Economic Co-operation and Development, 1967.

Jantsch, Erich. Technological Planning and Social Futures. New York: John Wiley & Sons, 1972.

Jones, Marvin V. A Technology Assessment Methodology: Some Basic Propositions, report prepared by the Mitre Corporation for the Office of Science and Technology, Executive Office of the President. Springfield, Va.: National Technical Information Service, June 1971.

Kahn, Herman and Anthony J. Wiener. The Year 2000: A Framework for Speculation. New York: Macmillan Books, 1967.

Land, Kenneth C. Social Indicator Models: An Overview. paper presented at AAAS meeting, December 26-31, 1972.

Martino, Joseph P., "Consistency of Delphi Forecasts," Futurist, IV (April 1970), 64.

Martino, Joseph P. Technological Forecasting for Decisionmaking. New York: American Elsevier Publishing Co., 1972.

Maruyama, Magoroh and James A. Dator, eds. Human Futuristics. University of Hawaii: Social Science Research Institute, 1971.

McHale, John. The Future of the Future. New York: George Braziller, 1969.

Meadows, Donella H., Dennis L. Meadows, Jørgen Randers, and William W. Behrens III. The Limits to Growth. New York: Universe Books, 1972.

Morgan, R. P., J. P. Singh, B. D. Anderson, and E. Greenberg. Satellites for U.S. Education: Needs, Opportunities and Systems. paper presented at AIAA 4th Communications Satellite Systems Conference, Washington, D.C., April 24-26, 1972.

National Academy of Engineering, Committee on Public Engineering Policy. A Study of Technology Assessment. prepared for the Committee on Science and Astronautics, U.S. House of Representatives, Washington, D.C., July 1969.

Parker, Edwin B. "1985," unpublished paper, Communications Department, Stanford University, [n.d.].

Polak, Fred L. Prognostics: A Science in the Making Surveys the Future. New York: Elsevier Publishing Co., 1971.

Ruch, Floyd L., and Philip G. Zimbardo. Psychology and Life (8th edition). Glenview, Illinois: Scott, Foresman and Co., 1971.

Sedlacek, W. C. et al. Summary Report: Information Transfer Systems Requirement Study. Lockheed Missile and Space Company, NASA-CR-73421, Sunnyvale, California, March 1970.

Shakespeare, William. Hamlet. New York: Signet, 1972.

Steinbeck, John. Of Mice and Men. New York: Signet, 1972.

Theobald, Robert. Futures Conditional. New York: The Bobbs-Merrill Co., 1972.

Turoff, Murray. "Delphi and Its Potential Impact on Information Systems." Fall Joint Computer Conference, 1971.